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FEBRUARY 20, 1979

A CAHNERS PUBLICATION

EDN

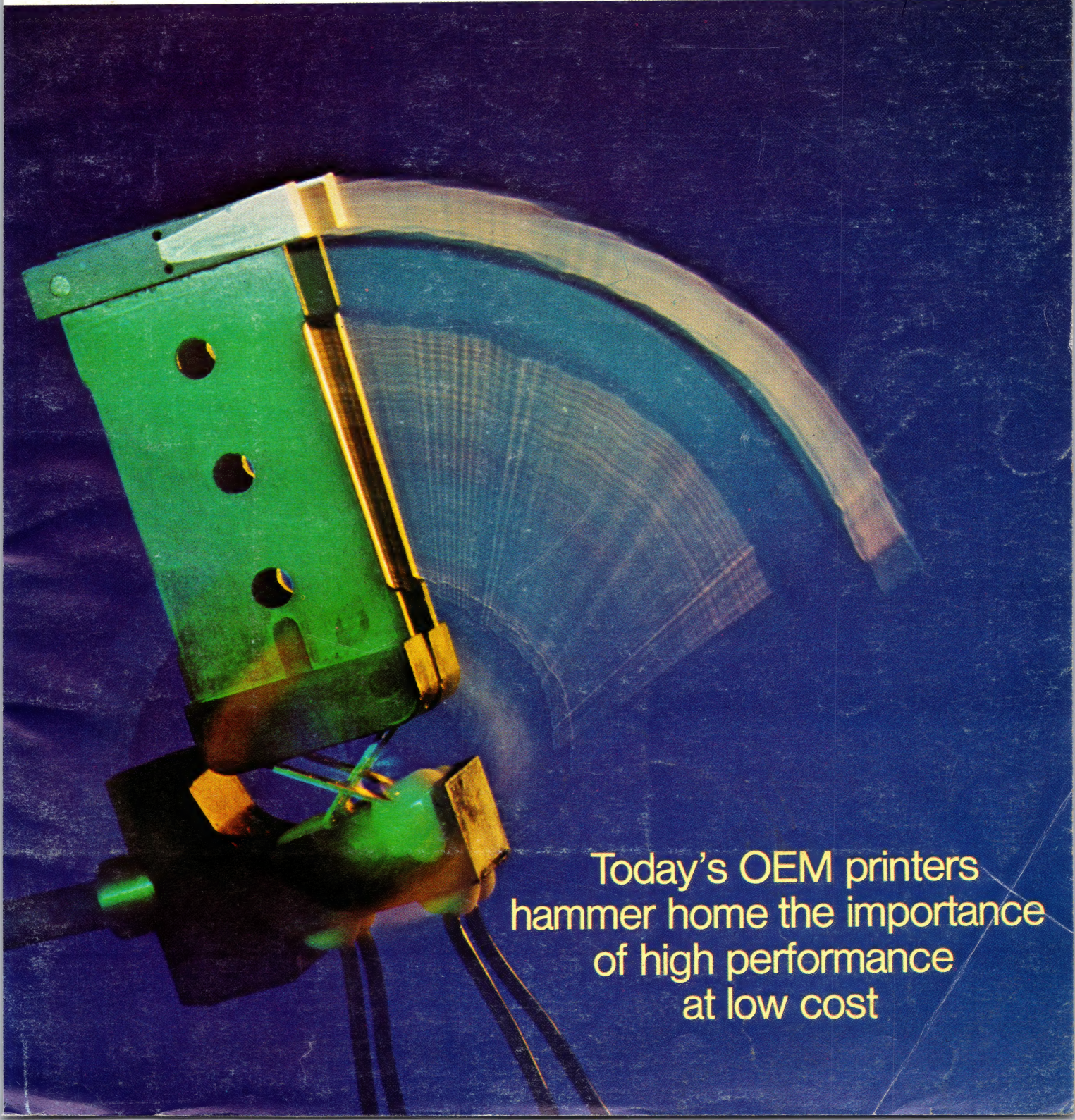
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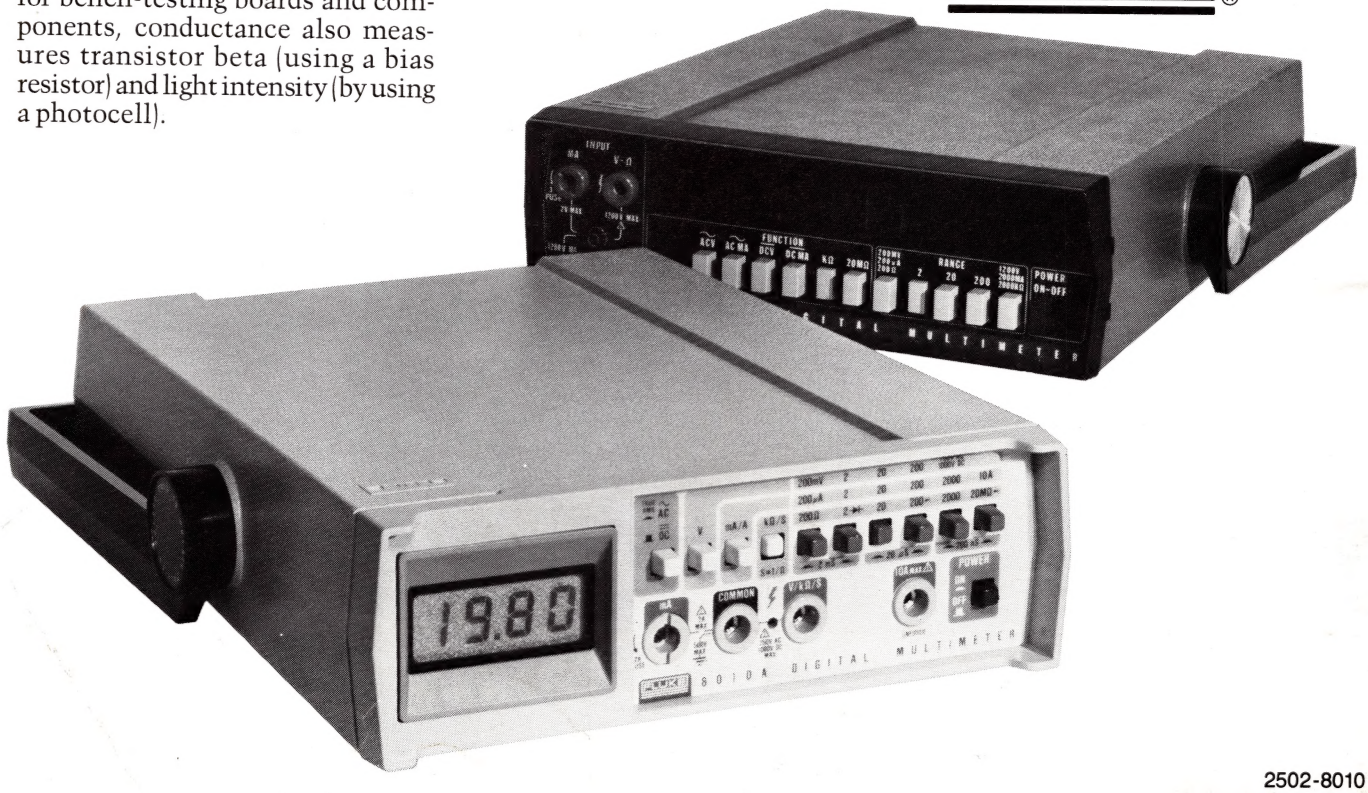
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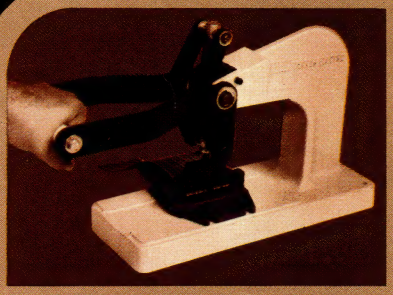
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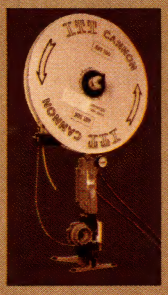
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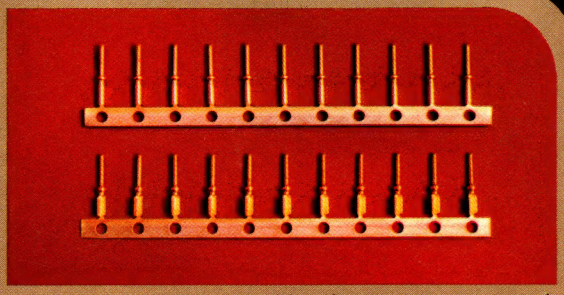


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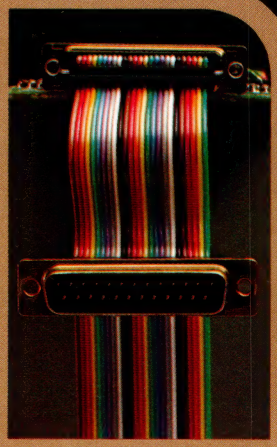
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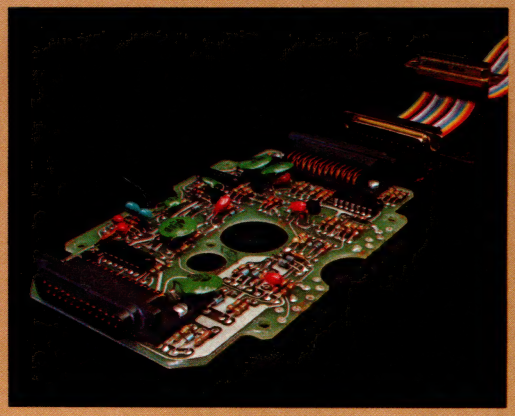
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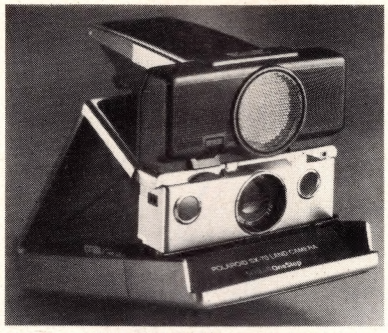
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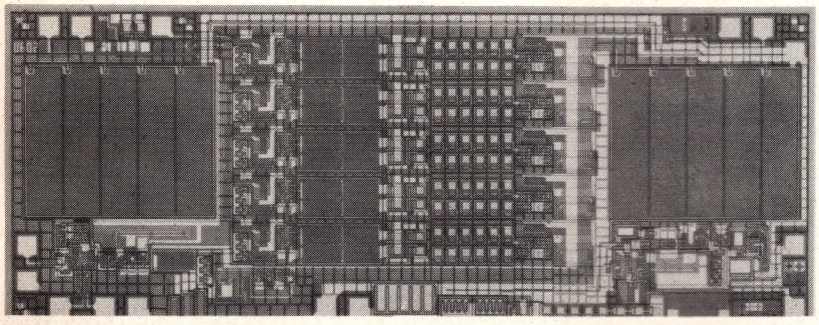
Technology News



On the first autofocusing still camera, *mirrors behind the windows flanking the Konica nameplate reflect images to a special comparator IC.*



The sonar approach *to automatic focusing characterizes Polaroid's SX-70. An ultrasonic transducer is located behind the grille directly above the camera lens.*



A photomicrograph *of Honeywell's Visitronic IC shows the segmented photodetector arrays at either end of the chip. On-chip processing circuitry determines when the images falling on the arrays match, indicating a correct camera focus.*

images for each segment, as well as checking the sum of segment outputs.

Although this multiple-segment approach requires more complicated chip circuitry than a simple one-to-one comparison, the sharper resolution and increased assurance of an accurate image match make the extra complexity worthwhile, according to Honeywell.

Separate circuitry in the camera translates the Visitronic IC's output into a control voltage for the camera-lens positioning solenoid. Movie cameras can use the same autofocusing system by substituting a stepping motor for the still camera's solenoid to furnish continuous lens adjustment.

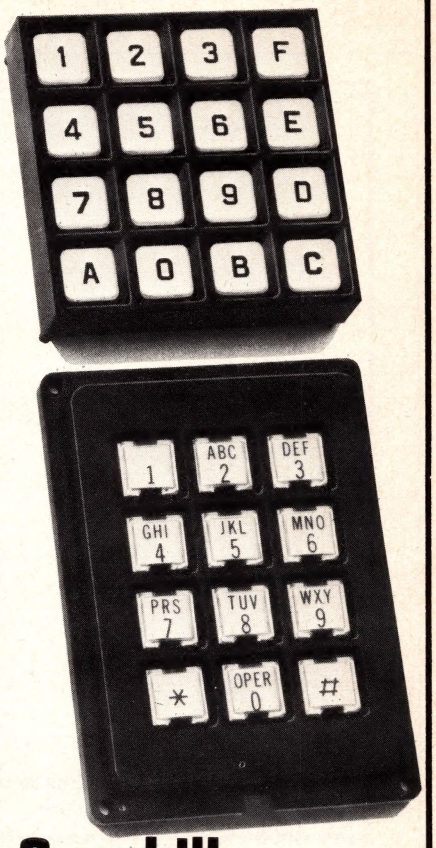
Visitronic systems complete the entire focusing sequence in less than 0.3 sec. The camera scans a subject, determines the correct distance, sets the proper lens-focusing position and takes the photo while the user presses the shutter button.

One disadvantage of this electronic image-comparison technique is that the silicon detectors must be provided with enough light to "see" the subject. But the detectors in the Visitronic chip overcome this obstacle by offering an unusually wide dynamic range of 5 to 5000 nits (a measure of luminance equal to 1 candela/m^2), enabling the camera to focus on scenes illuminated by candlelight as well as bright snowscapes.

Echo works in the dark

An alternative autofocusing technique eliminates potential low-light-level

Tested for Millions of Operations



Grayhill 12 and 16 Button Keyboard Pads

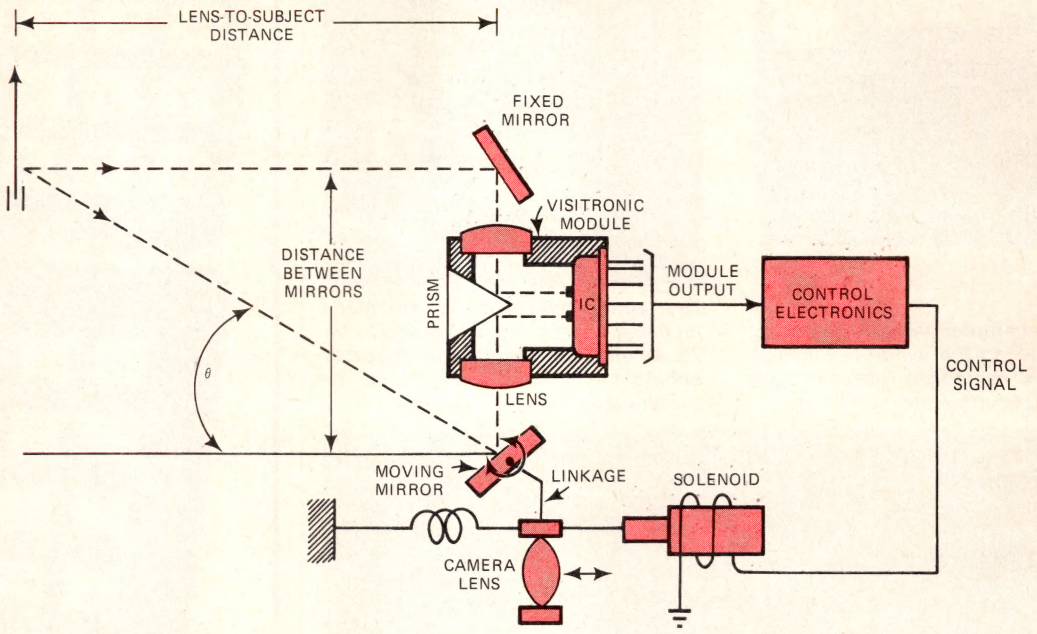
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Like conventional split-image focusing, *the Visitronic system uses optical triangulation methods to determine the optimum camera-lens position.*

problems by avoiding the use of light altogether. This sonar method—developed by Polaroid Corp, Cambridge, MA—employs ultrasonic echo ranging to determine proper focal distances.

Polaroid's sonar unit first appeared in its SX-70 Sonar camera—at a list-price increase of only about $16 over the firm's nonautofocusing model. (In contrast, Konica's Honeywell-based autofocus camera commands nearly a $100 premium.)

The Polaroid sonar system contains five basic elements: a transducer, crystal clock, detector, accumulator and focusing motor. The critical part of the system is the dual-purpose—transmitting and receiving—electrostatic transducer, which consists of thin gold-plated plastic foil stretched over a metallic back plate; the foil converts electrical energy to acoustic energy and vice versa.

Transducer sends and waits

When a user depresses the camera's shutter release, this transducer sends out an ultrasonic "chirp" in an approximately 10°-wide cone toward the photographic subject. Simultaneously, a crystal - clock - controlled counter begins filling a 128-bit register and continues until the transducer detects a returning echo. Each register bit corresponds to a depth-of-field zone.

In the simplest case, when the counter has filled all 128 register positions without a returning echo (indicating a distant subject—at infinity), setting the last bit triggers the shutter and takes a photo with the lens still in its "park" position.

If the register is only partially filled when the transducer detects a returning echo (indicating a subject at a distance less than infinity), the focusing motor begins moving the lens away from the "park" position; the number of register positions filled at this point correlates with the distance to the subject. An encoder on the lens then generates pulses as it moves; these pulses fill the remaining register positions. (The number of positions remaining to be filled indicates the distance the lens must travel to obtain proper focus.) When the 128th register position fills, lens movement stops and the photo is taken.

Because this sonar technique utilizes only sound waves, its operation is unaffected by illumination levels. But the system does require a solid target to reflect its ultrasonic signal, so it can be fooled by subjects without substance, such as smoke. Anticipating this problem, Polaroid provides a manual override on the camera. **EDN**

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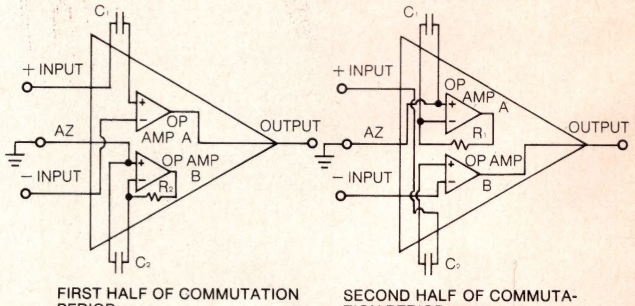
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FIRST HALF OF COMMUTATION PERIOD
AMPLIFIER A: PROCESSES INPUT SIGNAL
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SECOND HALF OF COMMUTATION PERIOD
AMPLIFIER A: AUTO-ZERO MODE
AMPLIFIER B: PROCESSES INPUT SIGNAL

AT THESE:

ONE PRINCIPLE. TWO CAZ AMPs.

Commutating Auto-Zeroing Operational Amplifiers. Commutating Auto-Zeroing Instrumentation Amplifiers. CAZ AMPs.

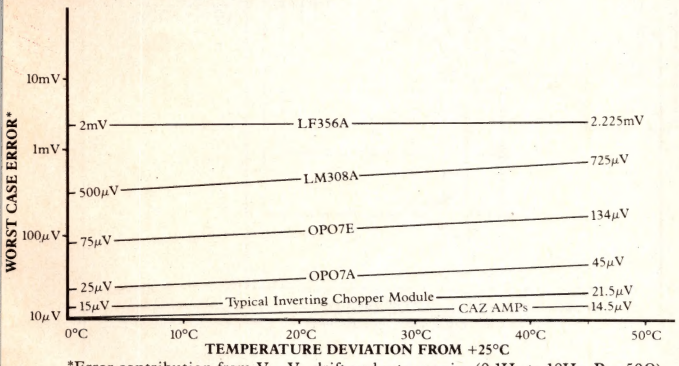
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*Error contribution from V_{os}, V_{os} drift and p-to-p noise (0.1Hz to 10Hz, $R_s = 50\Omega$).

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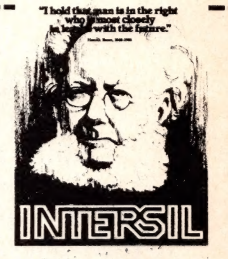
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8080 coding speeds reading of 12 bits

Jim Handy
National Semiconductor, Santa Clara, CA

In an earlier μComputerist Corner (EDN, Sept 5, 1978, pg 70), D W Taylor describes an excellent way for an 8080 to read data from a 12-bit A/D converter. As given, the operation increases input speed while significantly decreasing program length. But you can speed up Taylor's circuit with more powerful commands, thereby decreasing program length still further.

The trick lies in mapping the A/D address into memory space. This method allows you to use any memory-referencing instruction to address the A/D converter. These more powerful instructions include moves, loads and even pops (which are useful in interrogating many converters). True, address decoding requires more packages, because you're now examining 16 bits instead of eight, but the savings in software make up for both the added hardware and the 2-byte space used to service the converter. The increased versatility in memory-mapped I/O afforded by new addressing modes outweighs most disadvantages.

The number of software bytes used and the length of read times can be found by comparing routine lengths. For I/O-mapped read operations, you need to:

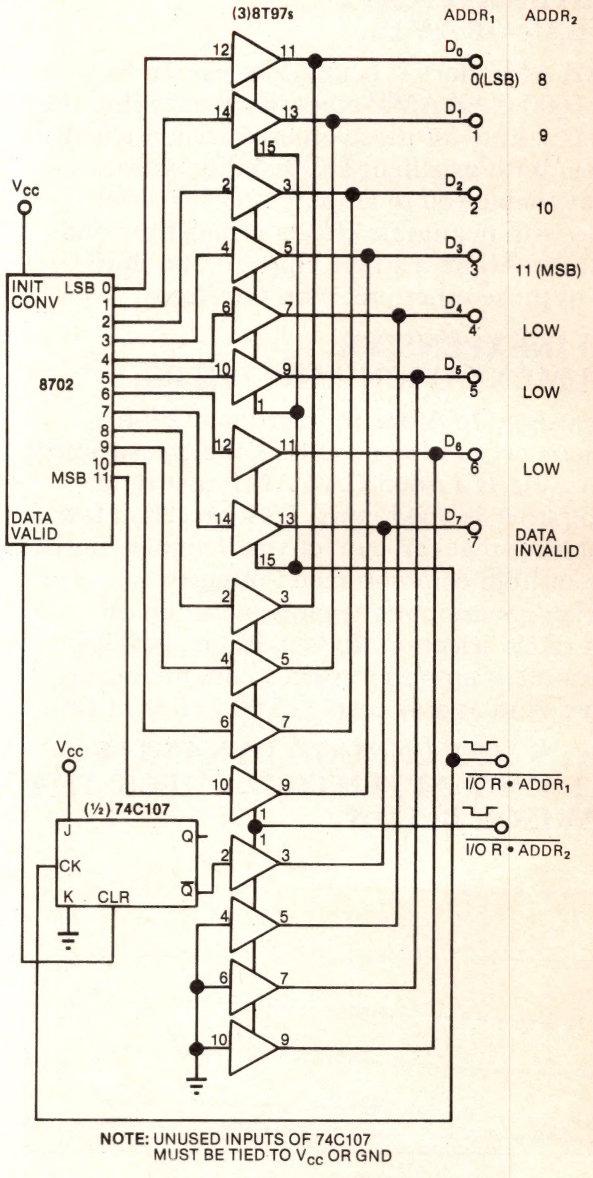
```
ADIN: IN   ADDR1
      MOV C,A      ;LOW-ORDER
                   ;BYTE TO C
      IN   ADDR2
      MOV B,A      ;HIGH-ORDER
                   ;BYTE TO B.
```

Counting the number of bytes needed to store these instructions and the number of cycles used to execute them reveals that this read operation utilizes six bytes of program and 30 clock cycles.

With memory mapping, there are several ways to streamline the program. If the HL register pair already points to the converter's low-order byte, then

```
ADIN: MOV C,M    ;READ LOW-ORDER
                 ;BYTE
      INX H      ;MOVE ADDRESS
                 ;POINTER
      MOV B,M    ;READ HIGH-ORDER
                 ;BYTE
```

uses 15 cycles and only three bytes. Unfortunately, this second routine ties up the HL registers as well as the BC registers.



NOTE: UNUSED INPUTS OF 74C107 MUST BE TIED TO V_{CC} OR GND

With software changes, *this circut lets you read a 12-bit ADC output with an 8-bit μC.*

NATIONAL ANTHEM®

ALL THE NEWS THAT FITS

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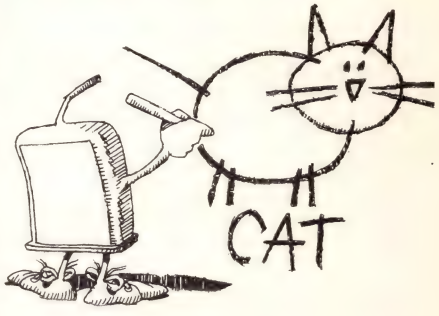
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It Can Draw It Can Write



The DP8350 CRT controller is the "cat's pajamas" for easy, flexible, cost-effective terminal design. As a one-chip solution to the essential control element of your monitor system, this device is equally effective in either graphic or alpha-numeric display.

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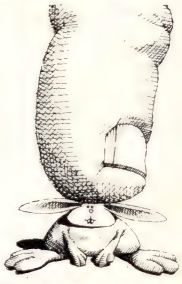
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Applications Corner

Our DP8350 CRT Controller is a versatile building block for both low- and high-end CRT terminal applications. The diagrams below show this device used for graphics applications.

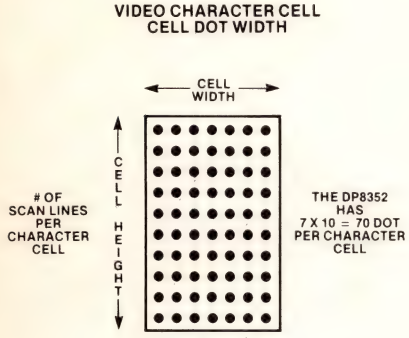


Figure 1: The DP8350 character cell is 7 dots wide and 10 dots high.

Figure 1 depicts the DP8350 character cell, with its unique, individual CRT memory address and its programmed potential of 7 x 10 or 70 dots. In a typical alphanumeric application, two columns and three rows of these dots are blanked, allowing character-to-character and row-to-row spacing. Thus the character is a 5 x 7 dot matrix in a 7 x 10 dot field. It is the character generator, not the DP8350 CRT Controller, that limits use of all dots in the character cell.

Figure 2 is a block diagram of a character generator graphics system. The character generator block contains a ROM programmed with graphic symbols to fit the character cell size. In this case, however, each of the 70 dots may have active video data. Continuity is provided by combining cells horizontally and vertically. If the ROM is programmed so that the full cell size is not entirely used, graphics as well as alphanumerics may be displayed on the CRT.

Character generator graphics is the simplest, most cost-effective approach to CRT graphics as it requires a minimum of system software and hardware development. The DP8350 CRT Controller provides all the required timing and control pulses for the CRT memory, character generator and CRT monitor.

This system provides character cell symbol control only. If individual dot control is required for a high-resolution graphics display, Memory Mapped Graphics may be used. In the latter case, every dot of the CRT display is mapped to a specific CRT memory data bit. Obviously, this is more costly as more CRT memory is required and the microprocessor overhead is greater. In any case, the DP8350 easily adapts to such a system also.

In Memory Mapped Graphics, each character cell is subdivided so that each scan line of the cell may be independently addressed. (See Figure 3.) The CRT memory block then provides 8 bits of direct video data, rather than 8 bits of data defining a character cell code to the character generator. The CRT memory block serves double duty: CRT memory storage and symbol or character generator. All the user has to do is convert this parallel video data to serial video data as before.

With the DP8350 internal ROM format program, each cell is 7 dots wide so only 7 bits of video data are needed per character cell/scan line address. The DP8350 addresses the memory block with the character cell address as before, but also adds in the scan line address. In this manner, the DP8350 series has a maximum address capability of 16 bits (64K).

Additional information about graphics and the DP8350 may be obtained from Application Note AN212, "Graphics Using the DP8350 Series of CRT Controllers."

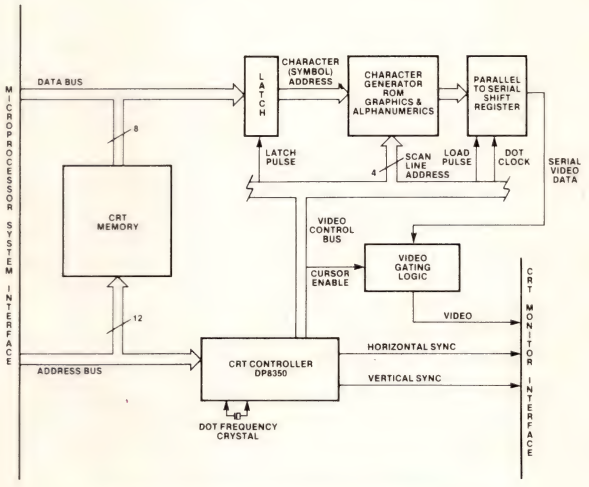


Figure 2: Character Generator Graphics

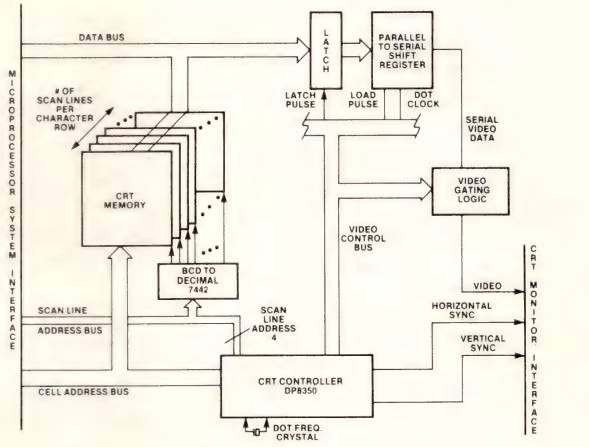


Figure 3: Dot by Dot (Memory Mapped) Graphics

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A Review of New Products and Literature from National Semiconductor

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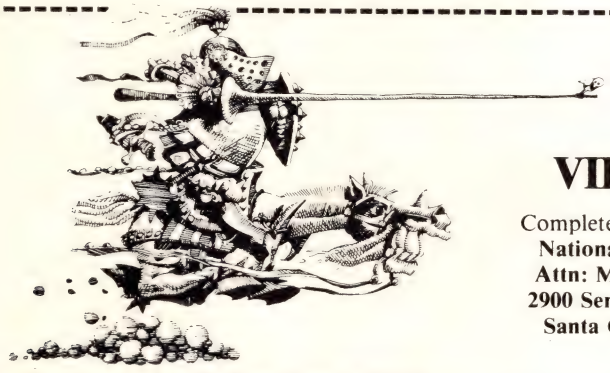
National has just announced three new add-in memories for major minicomputers that provide you with lots of extra features at less cost (naturally). All of them can be substituted for "major brands" with no additional tools.

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EDN 2/20 9-2

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Another method uses the HL register pair for data in lieu of the BC registers. In this case, the simple instruction

ADIN: LHLD ADDR1 ;READ A/D DATA

reads the converter, again in three bytes, but takes only 16 cycles to complete the read. This method uses 50% less memory space than the original scheme and executes 47% faster.

Be cautious when using this method, however. These programs load data from two adjacent memory locations, low-order byte first. Therefore, the two addresses in the figure—$ADDR_1$ and $ADDR_2$—must have this relationship: $ADDR_2 = ADDR_1 + 1$. **EDN**

SDK-85 routine displays full alphabet

Robert R Speers
Bowling Green State Univ, Huron, OH

Most 8-bit, 1-board μC demonstrators or trainers provide a 6-digit, 7-segment display (plus decimal points), which furnishes a cost-effective means for I/O and debugging from a keyboard. But these 7-segment displays can also be used to show a full alphabet of mostly upper-case letters plus some lower-case characters and punctuation marks. The required program (**Fig 1**) outputs a rotating alphanumeric message on an SDK-85's display. **Fig 2** shows the character shapes and the associated codes.

```
2000    212620    BEGIN    LXI   H, MESSAGE BEGINNING   Defines the location of
                                                        the message code.
2003    0E90      LOOP2    MVI   C, 90                  Formats the display con-
                                                        trol to the left-most
                                                        position.
2005    79                 MOV   A, C
2006    320019    LOOP3    STA   1900                  Store location of the
                                                        display control.
2009    7E                 MOV   A, M                   Set the code of the
                                                        character to be displayed.
200A    A7                 ANA   A                     Check for 00 code.
200B    CA0020             JZ    BEGIN                 Recirculate message on 00.
200E    320018             STA   1800                  Display the character for
                                                        a non-00 code.
2011    23                 INX   H                     Next character.
2012    0C                 INR   C                     Increment display position.
2013    79                 MOV   A, C
2014    FE96               CPI   96                    Test for 7th display
                                                        position.
2016    C20620             JNZ   LOOP3                 If not at 7th position,
                                                        display character.
2019    11FFFF             LXI   D, FFFF               If all 6 positions are
                                                        specified, wait for
                                                        period FFFF
201C    CDF105             CALL  DELAY
201F    11FBFF             LXI   D, FFFB
2022    19                 DAD   D                     Subtract 5 from character
                                                        code location indes.
2023    C30320             JMP   LOOP2                 Return to message output
                                                        routine with message off-
                                                        set by one position to
                                                        the right.
2026    FF        MESSAGE BEGINNING
2027    FFFFFFFFFF                                      Leading blanks.
202C    XX                                              Substitute message-code
                                                        characters from Fig 2.
YY      FFFFFFFFFF                                      Trailing blanks.
ZZ      00                                              The 00 code causes
                                                        recirculation of the
                                                        message through the
                                                        display.
```

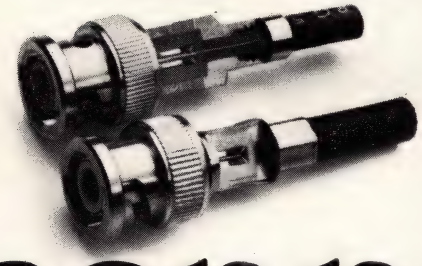
Fig 1—This SDK-85 program *runs a rotating-message-board (Times Square-type) display through the board's LEDs. The message starts at 2026 and uses the character codes in* ***Fig 2.*** *Five leading and trailing blanks ensure display readability.*

DISPLAY	ALPHANUMERIC	HEX CODE	DISPLAY	ALPHANUMERIC	HEX CODE
	A	88		t	78
	b	38		u	3E
	c	7A		U	1C
	C	6C		V	D9
	d	1A		W	3C
	E	68		X	B9
	F	E8		Y	19
	G	2C		Z	6B
	h	B8		0	0C
	H	98		1	9F
	I	9F		2	8A
	J	1E		3	0B
	K	D8		4	99
	L	7C		5	29
	M	CC 8D		6	28
	n	BA		7	8F
	N	8C		8	08
	o	3A		9	89
	O	0C		APOSTROPHE	EF
	P	C8		BLANK	FF
	Q	4C	•	TO ADD A PERIOD AT THE LOWER RIGHT OF AN ALPHANUMERIC, SUBTRACT EIGHT FROM THE CODE.	
	r	FA			
	S	29			

Fig 2—These character codes *and the resulting characters furnish a complete alphabet.*

Although some alphanumeric characters differ from their usual configurations, you can easily identify most of them. However, because of the absence of diagonal segments, a few letters—K, M, Q, W, X and Z—require artificial forms. Ms and Ws also require a double-width presentation. But with only a little practice, you'll be able to recognize all of the letters. **EDN**

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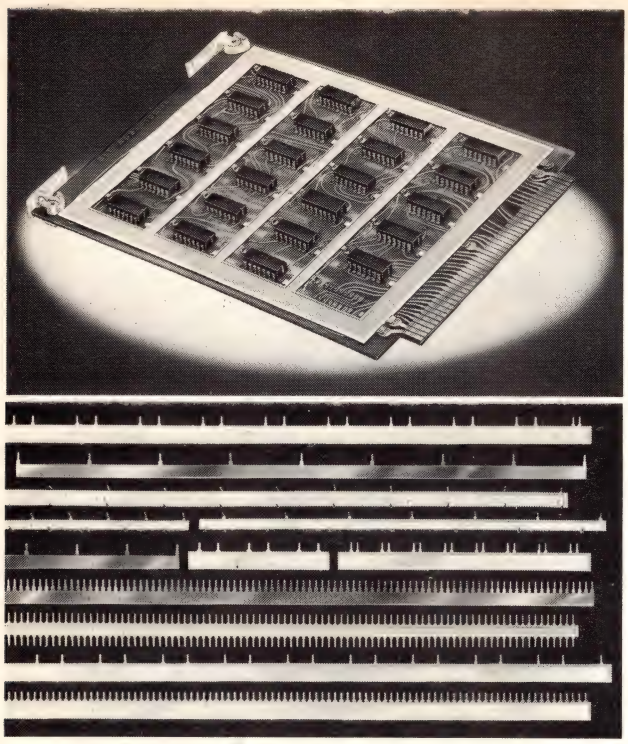
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μComputerist Corner

EDN Software Note #24

Shorten EDN's 8086 I/O routines

Jack Hemenway
Associate Editor

When you start out using a new chip, initial assumptions about it can lead you astray. In the writing of 8086 I/O routines (EDN, Jan 20, pg 81), an incorrect assumption (that I/O on an SDK-86 board occupies memory space) led to the inclusion of some unnecessary code.

You do *not* need to load the 8086's ES register or use segment override to output the contents of the μP's accumulator to the output ports. Because the I/O ports on the SDK-86 board don't reside in memory space, the output instruction (EE_{16}) sends the data to the address in the DX register; the data always goes to I/O. Thus, outputting a byte to parallel port P1A requires only the code shown in **a** of the **figure**; the routine in **b** shows how to input a byte from P1A. Note, though, that in memory-mapped I/O configurations, the original routines or ones like them are needed to correctly perform the desired tasks. **EDN**

(a)

```
; OUTPUT A BYTE TO P1A
;
        BAF9FF    MOV DX, 0FFF9H
;
; POINT DX REGISTER TO DATA PORT
;
        EE        OUT
;
; OUTPUT CONTENTS OF AL TO DATA PORT
```

(b)

```
; INPUT A BYTE FROM P1A
; BYTE RETURNED IN AL
;
        BAF9FF    MOV DX, 0FFF9H
;
; POINT DX REGISTER TO DATA PORT
;
        EC        IN
; INPUT TO AL FROM DATA PORT
```

In nonmemory-mapped configurations, *you can shorten EDN's 8086 input* ***(a)*** *and output* ***(b)*** *routines to two instructions each.*

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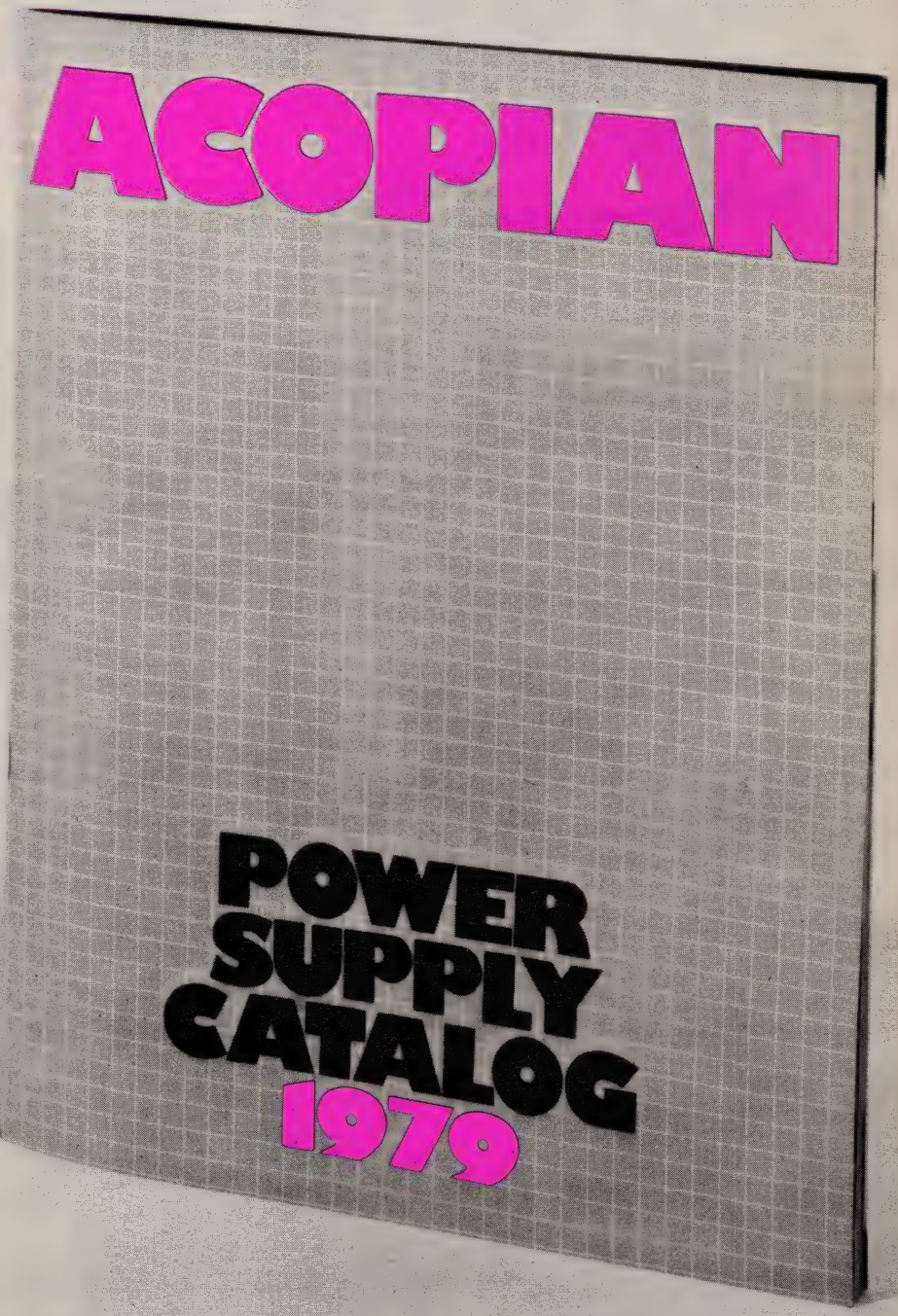
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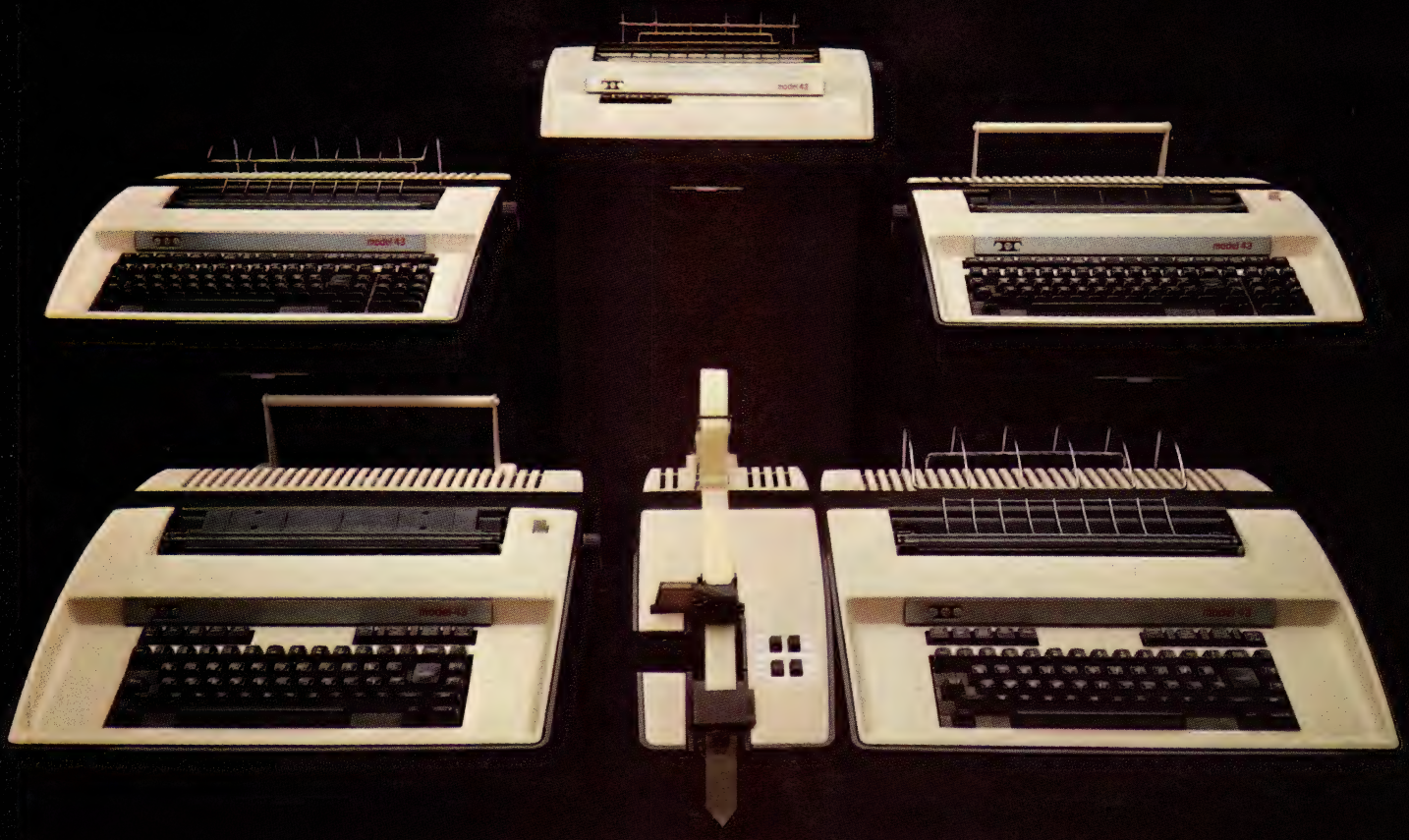


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When we introduced it just a year ago, the basic idea behind the Teletype* model 43 proved so sound and flexible that today it's grown into a comprehensive terminal family with extensive capabilities for message communications.

Model 43's come in a variety of configurations with either 80 column friction-feed or 132 column pin-feed printers. Some units are designed for use on the switched network, others for point-to-point private-line systems. (There's also a new generation of 5-level buffered teleprinters for Telex applications.)

The basic model 43 series operates on-line at 10 or 30 cps in either the half- or full-duplex mode and prints multiple copies using the 96 character ASCII code set. A wide choice of interfaces, including EIA RS232C and DC 20-60ma, are available for easy system integration.

With the automatic send-receive configuration, messages can be prepared off-line via the paper tape punch, edited, combined with a master tape, then sent at maximum terminal speed—automatically and unattended—when line rates are lowest.

Buffered 43's operate on-line at speeds ranging from 10 to 180 cps and provide up to 20,000 characters of storage for sending, receiving and editing. These terminals send and receive automatically via the buffer while messages are simultaneously being prepared for future transmission. They also include full forms control, the automatic answer capability and answer back.

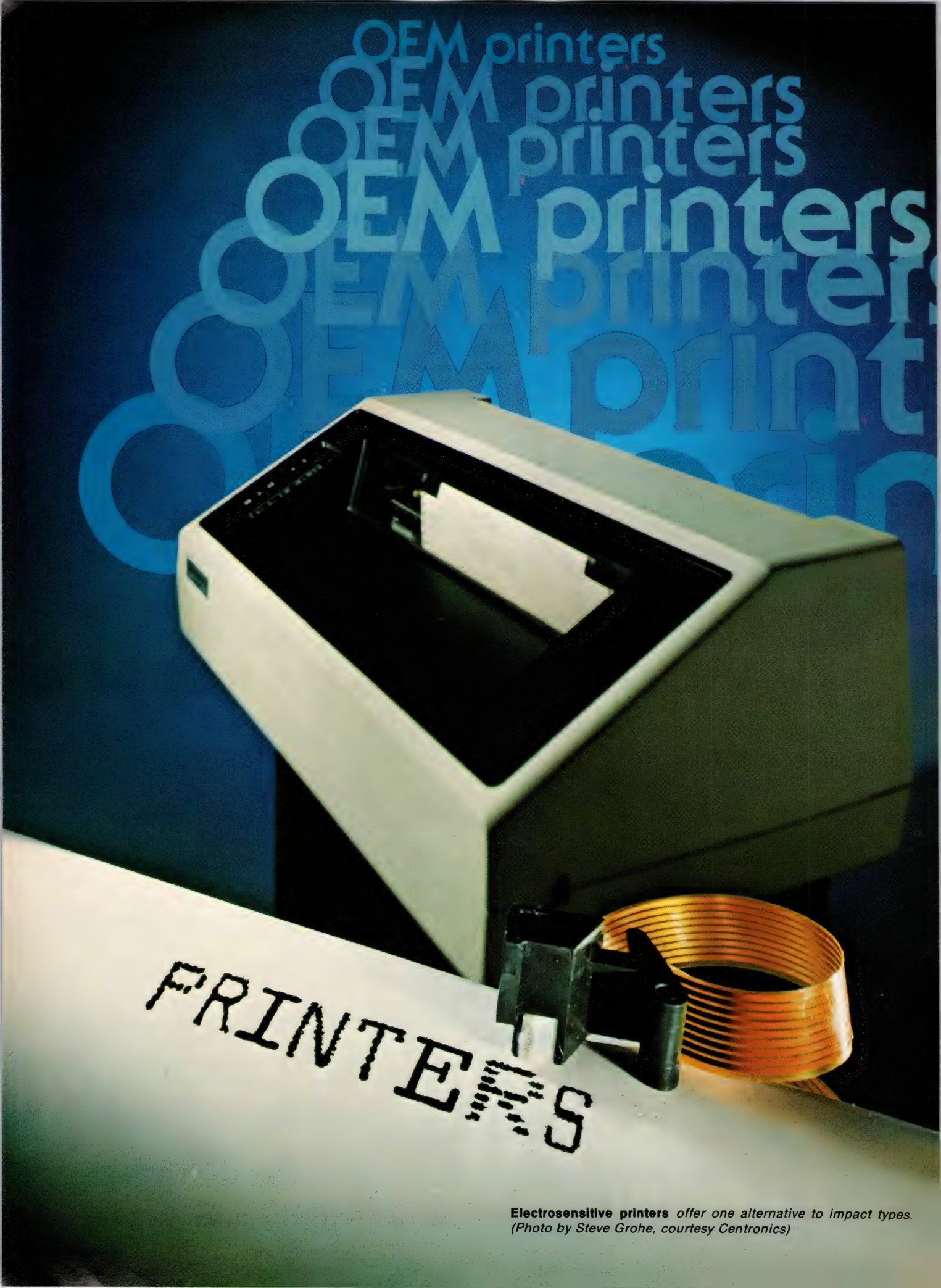
Just like its predecessor, the legendary model 33, our model 43 family is designed for extreme reliability. The reason is simple: simplicity. Our model 43's use only five major pluggable components (six, counting the paper tape module on the ASR), along with extensive use of LSI circuitry.

So when you think of our model 43 family, think of it as the beginning of a new legend.

THE TELETYPE MODEL 43 FAMILY.

Teletype Corporation, 5555 Touhy Avenue, Dept. 3185, Skokie, IL 60076. Tel. (312) 982-2000.
*Teletype is a trademark and service mark of the Teletype Corporation.

For more information, Circle No 43



Electrosensitive printers *offer one alternative to impact types. (Photo by Steve Grohe, courtesy Centronics)*

OEM printers

As the information explosion increases users' demands for hard copy, higher performance, lower cost printers emerge.

Sam Davis, Manager,
Western Editorial Office (South)

As printer companies try to keep pace with the ever-decreasing cost of computing power, they are increasingly moving toward the utilization of lower cost hard-copy techniques. This thrust toward more cost-effective printing is fueled by rising computer use, which International Data Corp, Waltham, MA, predicts will increase 1977's printer population 2.6 times by 1982. In that year, 600,000 printers should be in operation.

One of the major areas of computer-systems growth—distributed processing—will especially spur the use of lower speed, lower cost printers in the 1980s, says Dataproducts VP Irv Weiselman. The reason? This type of computer-system configuration replaces one expensive high-speed printer with multiple lower speed, lower cost units.

A second key factor in the increasing use of lower cost printers is the emergence of new telecommunications links. These systems (proposed by AT&T, IBM and Xerox), as well as new satellite-based communications operations, will call for additional printers. "People will be communicating more than ever before and will need printers for that," Weiselman observes.

A third factor governing the low-cost-printer explosion is the growth of small business systems. Industry estimates point to a potential of three million such systems in the 1980s, and those systems will require relatively low-cost, high-print-quality, moderate-speed printers.

The profile of a typical printer buyer is also changing. Ted Webster, president of Datek, a Fitchburg, MA printer-technology consulting firm, says greater numbers of first-time users are now considering printers. "In the past 5 yrs, systems houses and minicomputer companies were the ones who designed printers into systems. Now microcomputer usage will spur the individual use of printers tremendously. Almost everyone who configures such a computer system will need a printer."

Because the OEM printers used in computer systems are available either as complete units, as bare-bones mechanisms or as partially integrated subsystems, a knowledge of mechanisms, interfacing and drive circuits proves useful to potential printer users. We'll cover all of these topics in this Special Report.

Sorting out technologies

First, a quick review of the basics. Printers are classified as impact or nonimpact types. The former use mechanical force to transfer character forms to paper, usually through use of an inked ribbon; the latter are quieter but cannot



Shown here in its needle (impact dot-matrix) version, *the printhead for Siemens' PT-80 printer also comes in an ink-jet configuration.*

produce multiple copies in a single pass.

An impact printer can employ either fully shaped characters or a matrix of dots to produce an impression. Shaped characters are formed when ribbon and paper are struck by a print hammer—an electromagnetic device activated by the required data commands; dot-matrix characters usually utilize a 5×7 or 7×9 format.

Another way of classifying printers is by the method they use to generate character strings. A serial printer produces one character at a time by means of a head that moves either left, right or bidirectionally across the paper. With a line printer, on the other hand, all characters in a line are printed simultaneously; these devices are generally faster and more expensive than serial printers. In most printers, paper is advanced from line to line under control of a stepping or linear-rotation motor.

Impact printers

The oldest type of impact printer is the drum type, which produces fully shaped characters from their mirror images embossed on a drum. Upon actuation of a print hammer, the character image is transferred to paper via a ribbon. Throughput for a drum printer ranges from 10 cps for a serial configuration to about 2000 lpm for a line unit.

Although drum-printer use is diminishing in data-processing applications, these devices still find extensive usage in MICR (magnetic-ink code recognition) printing on checks, in ticket printing and in production of point-of-sale labels. The drum printer's major advantage is its relatively long lifetime—15 to 20 yrs. A disadvantage is the difficulty of replacing the entire drum—a necessary action if you want to change type fonts and print a different character set.

In a chain/train type of impact printer—which can achieve throughputs of more than 1000 lpm—type slugs containing embossed character forms move on tracks past a bank of print hammers. Unlike drum designs, these printers move their character fonts horizontally. Thus, timing variations shift character spacing horizontally in a chain/train system but produce a noticeable vertical shift in a drum unit. Chain/train printers are more flexible than drum units because their individual type slugs are easily replaced. But they require lubrication to minimize track wear; in contrast, drums rotate on bearings and thus exhibit virtually no corresponding wear problems.

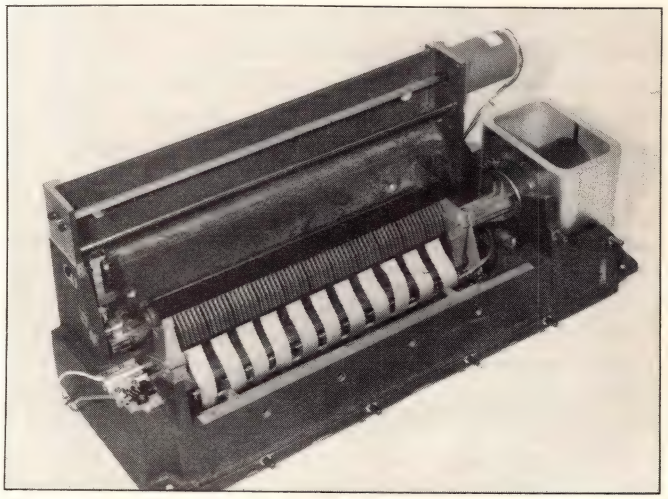
Band printers increase cost effectiveness

Replacing both drum and chain/train printers in many applications, the band printer uses an endless-loop steel band containing several complete character sets. This motor-driven band moves laterally at a constant speed in front of print hammers; printing occurs when the unit, scanning stored data in synchronism with the moving band, actuates the appropriate print hammers at the proper time. Band printers output 75 to 2000 lpm and are manufactured by Centronics, Control Data, Data Printer, Dataproducts and Documation, among others.

Centronics product manager Frank Gianattasio views the band printer as a more cost-effective technology than either the drum or chain/train type. He says a band printer's cost of ownership is considerably lower because this



Converting the Teletype Model 40 line printer *to a Dataproducts or Centronics parallel interface, Innovative Electronic Systems' C/D-40 interface board provides compatibility without software or hardware changes. It contains a full line buffer, automatic motor-control turn-off, selectable parity and extended ASCII, and a carriage return that can be ignored, or converted to line feed by a strap option. An 8085-based version of the Miami Lakes, FL company's board will be available this year; it will provide virtually all of the possible serial and parallel interfaces for the Model 40 printer.*



A linear voice-coil motor *shifts the print-hammer bank five dots horizontally to generate dot-matrix characters in Hewlett-Packard's 2608A line printer. Each of the 132 tines in the bank is shifted, so a full line can contain 132 characters and be produced at 400 lpm for 5×7 or 320 lpm for 5×9 (upper- and lower-case) matrices.*

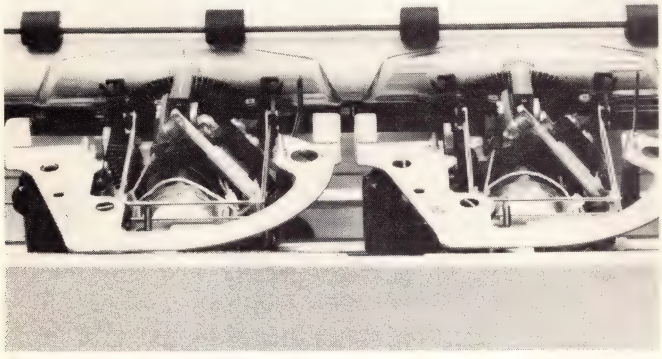
printer type is more reliable, easier to service and less expensive. (A typical $5000, 300-lpm band printer costs about 20% less than a drum printer with comparable performance specs. A comparable chain/train type costs about 60% more than such a band unit.) Parts commonality is another plus. Centronics' 75-lpm band printer uses about 85% of the same parts as the firm's 600-lpm unit; commonality between 300- and 600-lpm units is about 95%.

Further evidence of band printers' growth in popularity is the B Series from Dataproducts. In these units, a cost reduction compared with equivalent 300- to 600-lpm drum units results from the utilization of a rare-earth permanent-magnet print hammer. Hammer drive current thereby decreases from 1.8 to 0.8A and allows the use of the ICs instead of discrete drive transistors. Power-supply requirements also decrease, and forced-air cooling is eliminated. Finally, the printers' reduced size and weight allow use of a reinforced molded-plastic case instead of the more expensive machined-metal case of the older drum units.

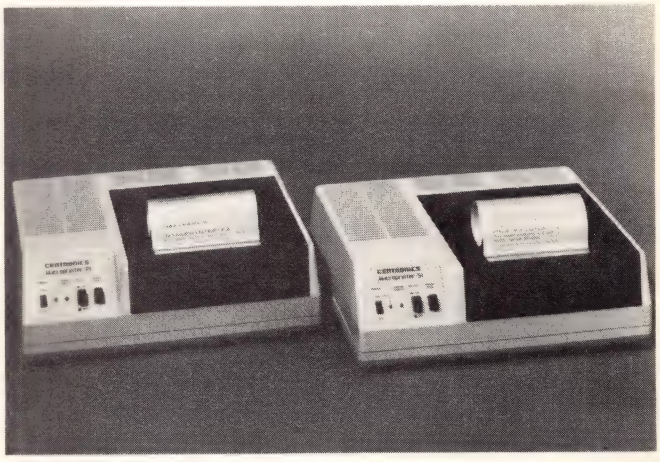
Dataproducts VP Bob Wallstrom discloses that the B Series printer incorporating rare-earth permanent-magnet hammers costs 65% less to manufacture, even though hammer cost has increased by 10%. As an additional benefit, use of the new material and other improvements have increased the time between required adjustments from 50 million to 500 million actuations.

Another feature of the B Series band printers is built-in diagnostics, which continually monitor machine status. When an off-line condition occurs, a display indicates it and notes whether it is operator correctable. And a built-in self-test feature allows an operator to run the printer independently of host-system control.

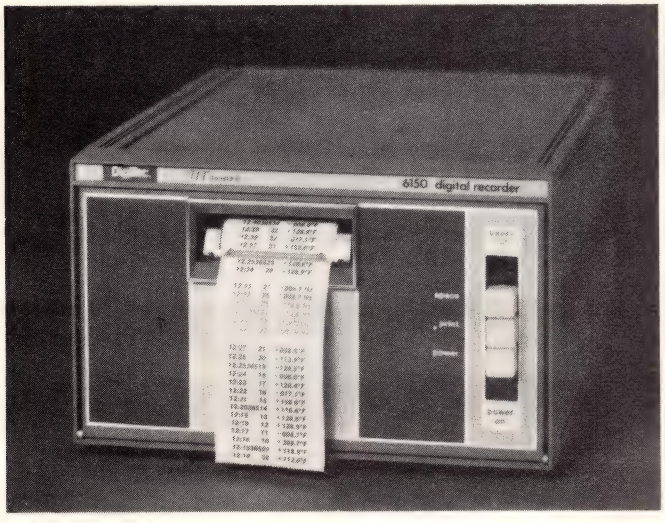
Such diagnostics are one of the beneficial side effects of the switch to μP control. Both the Dataproducts and Centronics band printers employ μPs, and although the initial cost effectiveness of μPs compared with random logic might be



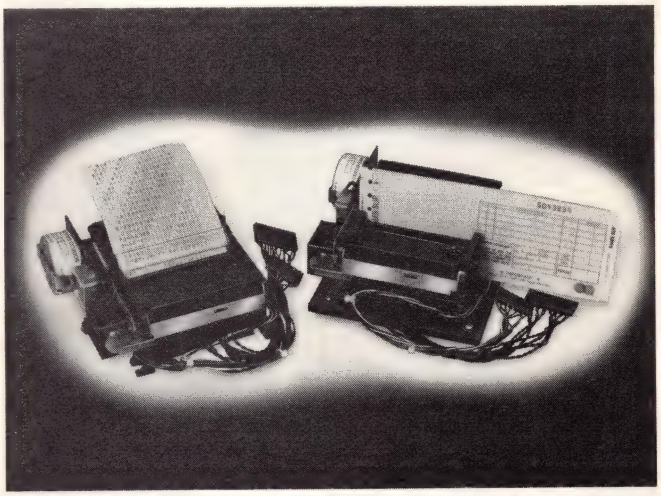
Two daisy-wheel printheads produce 75 cps *in Qume's Twin-Track printer—a feature that allows simultaneous printing with two type fonts or two languages, in up to four colors.*



Serial- and parallel-interface versions *characterize Centronics' 150-lpm 5×8 dot-matrix electrosensitive Microprinter. The serial version has an RS-232C interface with parity selection, 50- to 9600-baud operation and 192-character FIFO buffer.*



An integral crystal-controlled clock *records real or elapsed time on a 4-digit hours/minutes printout in Digitec's 6150, an 18-column numeric printer. This drum impact unit also contains an integral event counter that produces a 3-digit sequential count ranging from 000 to 999.*



Accepting parallel TTL or serial ASCII, BCD or RS-232C input codes, *the μP-based controller for Sheldon-Sodeco's PR Series printers provides signal conditioning, complete buffer storage, timing control, handshaking, character generation and solenoid control. The drum printer's characters are generated by combinations of line segments struck by print hammers.*

Band printers improve performance through reliability, commonality

debatable, once a microprocessor is used, diagnostics are a relatively low-cost addition. And don't forget that the use of a μP also permits the easy implementation of new system-interface features.

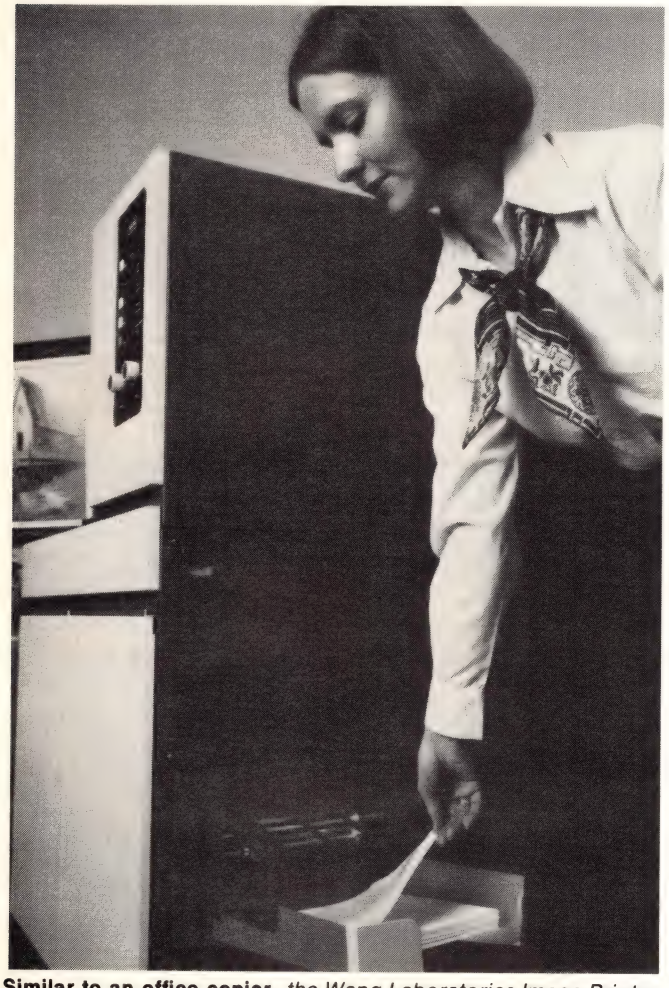
Serial-impact units strive for quality

The two most widely used serial impact-printer models continue to be the dot-matrix and full-character printwheel types. The former provide faster throughput, but the latter offer higher quality characters.

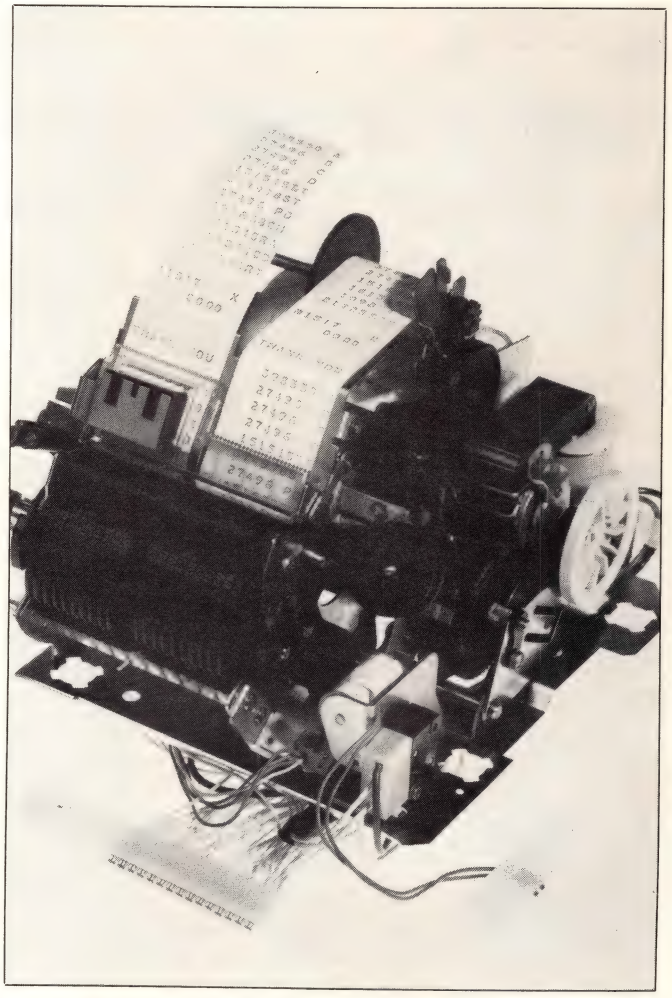
Printwheel (or daisy-wheel) printers employ a metal or plastic wheel, whose spokes contain embossed characters at their tips. To print a character, the wheel is rotated to the desired character form and a print hammer is activated, pressing the wheel tip against the ribbon and paper. The leading suppliers of these printers are Qume and Diablo; speeds range between 30 and 55 cps for single-printhead units. NEC supplies a unit that uses a print cup—similar in operation to a daisy wheel.

Microprocessors control carriage positioning and character selection in the Qume and Diablo units; they accept input data and determine the most efficient direction (clockwise or counterclockwise) to move the printwheel in order to reach the appropriate character. When the μP confirms that the carriage, paper feed and ribbon are at rest (to avoid smearing and incorrect character placement), it fires the print hammer. The carriage and printwheel dc servo motors each incorporate an encoder that supplies feedback to control angular position and speed: Qume uses an optical encoder; Diablo's is magnetic.

In conventional dot-matrix impact printing, characters are formed by selectively activating combinations of vertical print wires, which hit a ribbon to produce dots on the paper as the printhead moves horizontally. The dot-matrix approach provides much greater flexibility than possible with a full-character printer, because it allows production of graphics and the easy addition of new character fonts via software.



Similar to an office copier, *the Wang Laboratories Image Printer employs a CRT/fiber-optics print mechanism to attain 1600-characters/min speed and typewriter-quality printout. Selective paper handling eliminates the need for special document-handling devices or manual intervention in paper feeding.*



For cash-register and data-logging applications, *Addmaster's Model 60 drum printer uses two printheads to produce two separate printouts. Each printout contains 10 columns of data; printing speed equals 3 lps.*

But some 5×7 dot-matrix printers suffer from poor print quality caused by gaps between adjacent dots—a disadvantage accepted by some users as the price of low-cost printing. Some manufacturers, however, now use more sophisticated printing approaches, whereby dots are impacted closer together to provide better print quality.

In one of these new higher resolution dot-matrix printers—the Sanders Technology Systems Media 12/7—a 7-pin printhead is controlled by a μP, which regulates both horizontal dot placement and vertical dot positioning. Horizontal printhead passes, interlaced with vertical paper motion, place dots on the paper—an approach that allows great flexibility. Reducing the number of passes per printed line from four to two increases speed at the expense of print quality. Optimum printing speed is thus a function of type size, desired quality and the speed of the printhead (12 ips). For example, the printing speed for a 4-pass, 12-pitch, typewriter-quality typeface is about 36 cps; a 1-pass, 18-pitch character set outputs at 216 cps.

Printronix uses a different approach to obtain higher resolution printing in its 150-, 300- and 600-lpm units. These printers employ a bank of 44 print hammers mounted on 0.3-in. centers with a common permanent magnet; the applied magnetic field latches the hammers in a retracted position until they are individually released by a current pulse through a coil associated with each hammer. Under cam control, the entire hammer bank is shuttled horizontally so that each hammer shifts enough to cover the space between itself and the adjacent hammer. When a hammer's coil experiences a continuous series of pulses, the hammer is released at appropriate intervals, producing a series of overlapping dots.

Nonimpact printers

Nonimpact printers continue to grow in popularity, reflecting their inherently quieter operation compared with impact types. Among the most popular approaches to nonimpac printing are: electrophotographic (xerographic), ink-jet, thermal, electrosensitive and electrostatic.

A 1978 report from International Resource Development (IRD), New Canaan, CT, notes that "despite the introduction of increasingly attractive and quiet impact matrix printers from several manufacturers, nonimpact technologies are more than holding their own in most market sectors. Based upon factors such as reliability, high speed, silence, low cost and portability, nonimpact units have quite successfully competed with impact printers in markets as diverse as computer-output printing, word-processing printing and interactive time-sharing."

To date, most very high-speed nonimpact printers (laser-xerographic systems from IBM, Xerox and Siemens, for example) have also been very expensive—some cost well over $100,000. Such "super printers" primarily serve large data-processing systems, but several companies are now also applying electrophotographic techniques to lower cost, lower speed systems oriented toward OEM use. Price/performance goals for these units aim at a cost less than $20,000 for throughput of 1000 to 5000 lpm. The devices, termed intelligent copiers, should become available within the next 2 yrs.

Although intended for use in the company's word-processing systems, Wang Laboratories' intelligent Image Printer seems to be a step in the direction of such lower cost, high-speed, high-print-quality nonimpact printers. It outputs 18 pages/min with typewriter-like print quality and a resolution of 90,000 dots/in.^{2}, and it costs $35,000.

The unit's printing function is initiated by a print request from the word-processor disc through a μP-based control unit, which assigns print commands and selects the font and type sizes specified by the operator. A character generator then converts the digitized information slated for printing into visual images, displayed one line at a time on a high-resolution, high-brightness CRT. As each full line is displayed, it's scanned, and the resulting light pulses are transmitted by fiber optics to twin photoreceptors directly above the paper and hence to the paper itself. The paper is thus sensitized at each point where an image is required. A dry toner bonds to each of these points, creating the desired image; then brushes sweep the unused toner from the paper. This printer class has the advantage of using plain bond paper; most other nonimpact types require special paper.

Ink-jet units print on demand

Vying with electrophotographic units, ink-jet printers are now also becoming available for OEM applications. The first word-processing-oriented ink-jet unit was the IBM 6640, which uses a continuous-droplet (synchronous) approach. In this device, uncharged ink pumped through a 0.001-in.-diameter nozzle passes through a charge electrode and breaks into droplets that are individually charged in response to data fed to that electrode. The droplets then pass through deflection plates and are deposited on paper; thus each character is formed drop by drop. Average throughput equals 54 lpm for continuous printing over a 6-in. line.

Another technique for ink-jet printing is Silonics' drop-on-demand (asynchronous) system. Priced an order of magnitude less than synchronous systems, this $2500 unit achieves 180-cps

Dot-matrix units are flexible, but sacrifice print quality

operation—120 lpm for an 80-character line.

In operation, ink flow comes from seven independently controlled ink-ejection chambers, each of which consists of a piezoelectric transducer, ink-delivery channel and nozzle. Upon receiving dot-matrix-character commands, each transducer inwardly deforms a wall of the corresponding ink channel; the sudden slight reduction in channel volume causes ejection of an ink drop from the associated nozzle. A pressure regulator built into the printhead keeps the ink-delivery channels filled. Ink is thus ejected only as needed, in contrast with synchronous systems, which continuously emit droplets, then collect, clean and recirculate unused ink. Gould also offers a drop-on-demand ink-jet printer.

Siliconics marketing manager Doug Vaughn explains that one of the major disadvantages of the synchronous ink-jet approach is start-up and shut-down problems, commonly termed "morning sickness." He claims the drop-on-demand approach allows a more cost-effective means of accomplishing printer start-up and shut-down. Synchronous units are also more subject to jet clogging, caused by recirculated ink. Another advantage of drop-on-demand printing is a less critical dependence on droplet size. (In a synchronous system, droplet deflection—hence droplet positioning—depends on droplet size.)

The paper used with ink-jet systems must be an absorbing type, otherwise smearing occurs. Vaughn says the absorbing papers available show varying degrees of acceptability; one of the best is conventional Groundwood Teletype paper. A competitively priced whiter paper with improved resolution also finds use today.

Printhead action critical in thermal units

Thermal printing is one of the older nonimpact techniques; it uses printheads that apply heat to special paper to produce images on that paper. The heads can consist of arrays of either silicon mesas or resistive-film dots.

The leading supplier of thermal printheads is Texas Instruments, which offers silicon-mesa types. The firm's basic printhead consists of a matrix of electrically and thermally isolated heating elements; during printing, the mesas are selectively electroresistance-heated to a peak temperature of 200 to 260°C.

TI product manager Marvin Morris says the silicon printhead's hardness allows continuous contact between it and the paper; unlike resistive-film heads, it requires no lifting between print cycles. TI can achieve 60-cps operation with its printheads, but Morris feels that speeds three to four times greater will eventually be possible through use of new materials technology and printing techniques.

TI's EPN5200A printhead provides a continuous dot line containing 200 elements, spread across a 2-in. length. Consisting of 20 silicon chips mounted on a ceramic substrate, it can print from up to 100 elements at one time. An SCR included with each of the dot elements on a chip controls that element; a 5.6 to 18V pulse with a 100-nsec rise time turns on each element. SCR action keeps the element on until V_{CC} drops below 1V. Reliability is rated at 10^7 dot-line prints.

In addition to printheads, TI will also offer complete thermal-printer assemblies this year. One such assembly, the EPN9112, can produce a 12-character, 7-row×5-column alphanumeric matrix; the EPN9120 has a 20-character/line capability with the same format.

Representing one resistive-film-head approach, Hewlett-Packard's Model 9876A 80-column thermal graphics printer achieves 480-lpm throughput by means of a fixed head assembly with one resistor for each dot position—560 in all across the printer's 185-cm line. The $3500 unit prints one entire line of dots at the same time—effectively, it's a thermal line printer.

Electrosensitive units stress accurate control

Competing with the thermal printer for applications requiring small low-cost printers, electrosensitive units print on a special paper composed of a conductive backing and a thin metallic coating deposited over a dark undersurface. When 30 to 45V is applied to a printhead's 7-wire tungsten electrode as it passes over this paper, the metallic coating burns off and exposes the dark undersurface—producing the desired dots. Changing the voltage's amplitude or duration varies the dot size.

Electrosensitive printouts have long shelf life because they are unaffected by heat, sunlight or moisture—all of which can affect thermal paper.

What is RS-232?

You can obtain information on this specification from the Electronic Industries Association, Engineering Department, 2001 I St NW, Washington, DC 20006. Send $6.90 per document copy and ask for EIA Standard RS-232: "Interface Between Data Terminal Equipment and Data Communications Equipment Employing Serial Binary Data Interchange." A companion document, "Industrial Electronics Bulletin No 9—Application Notes for EIA Standard RS-232C," costs $3.50.

And the electrosensitive technique allows accurate control of printed marks; small readable characters can be readily printed. (By contrast, impact units can't print comparably small readable characters because the ink in their ribbons diffuses when it contacts the paper.) One disadvantage of the older type of electrosensitive paper—reflections from its shiny gray metallic surface—has been overcome with newer, whiter papers.

Axiom VP Simon Harrison sees electrosensitive printers predominating among future low-cost units because of their higher speed, better print quality and use of lower cost paper compared with thermal printers. (Electrosensitive-paper costs run roughly half as much as with thermal units.) He says impending improvements in electrosensitive printing include a printhead with hundreds of electrodes; it remains stationary as the paper moves. This approach permits the generation of high-quality graphics as well as alphanumerics, and it can produce halftones—a difficult job for other impact and nonimpact technologies.

One of the most noteworthy electrosensitive printers—a rotary unit from SCI Systems—utilizes a printhead that contains three multiwire stylus assemblies mounted 120° apart on a

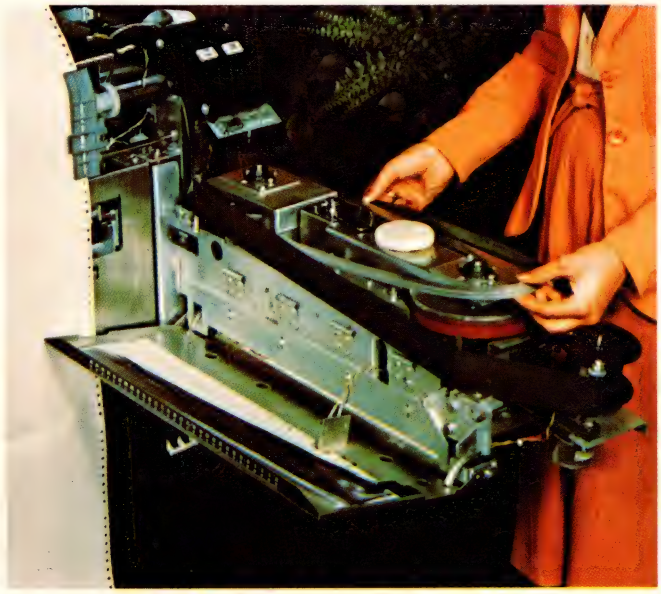
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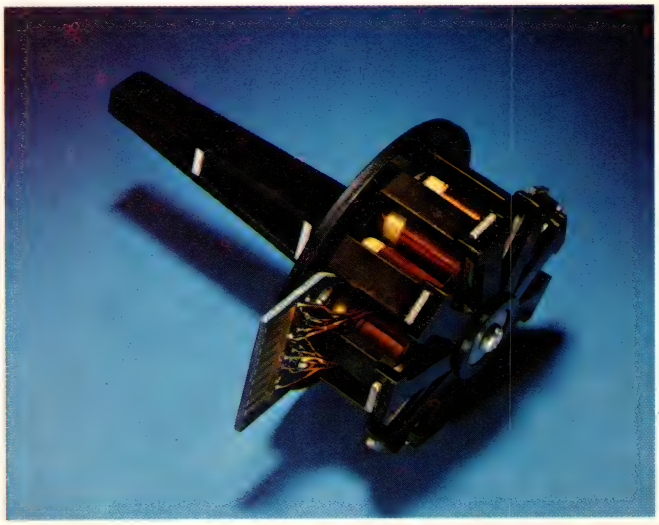
A 2-column, 14-wire printhead *in Dataproducts' M-200 dot-matrix printer uses look-ahead logic to provide 320-cps operation and an average 200-lpm throughput. The logic determines the first and last character position in the next line to be printed; upon completion of a line, a μP routine moves the printhead directly to the start or end of the next line—whichever requires the least time. The bidirectional M-200 then prints left to right or right to left, as required.*



Anticipating the growth of computers in the office environment, *the DEC LA34 runs more quietly than a standard typewriter. It prints upper- and lower-case data in a 9×7 dot-matrix format and accepts rolls or sheets of paper. The unit prints at any of four character sizes, including a compressed font that achieves 216 characters/line. A special-purpose μP allows selection of type font, tabs and margins through a Set Up key.*



Weighing less than an ounce, *the band in Control Data's Model 9380 line printer can be replaced in less than 30 sec. Once a new band is in place, the printer automatically adjusts to the character-set size as well as to a character density of 10 or 15 cpi.*



Rated at 250 million characters, *the dot-matrix printhead in Lear Siegler's 300 Series Ballistic printers has no moving cores attached to its impact wires, as do some solenoid-driven printheads. Instead, the free-falling wires are propelled to the ribbon and platen by the electromagnetic force of surrounding armatures. A 7×9 matrix allows underlining and lower-case descenders.*

Printer ICs reduce component count

In the past, printer interfaces used general-purpose SSI and MSI and discrete transistors. But the advent of the μP and improvements in ICs have helped to simplify such interfaces, although the large number of available printers has limited the number of ICs designed to serve specific units.

The Intel UPI-41 is one such IC; it serves the LRC Model 7040, a 40-column, 5×7 dot-matrix impact printer. **Fig 1** shows a block diagram of the UPI-41 software for the 7040. The buffer manager (BMGR) is responsible for all host-processor interaction; its data structure contains a 40-character buffer that stores characters as they are received from the host processor. The printer-service routine (PSR) uses the timer to keep track of the printhead's current position. At the appropriate times, it pulses the printer's solenoid drivers to produce characters.

Also intended for use with the 7040 printer, Rockwell's R7000 μP contains (in ROM) the dot-matrix code for 64 USASCII characters, plus all circuitry required to control the 7040's seven print solenoids. It also senses the status of various switches necessary to print single- or double-width characters, controls single or multiple paper feeds and allows serial or parallel communication with the host processor.

Another Rockwell printer-controller μP is the R6500/1 **(Fig 2)**, a 1-chip version of the firm's 8-bit R6500. Its ROM program serves eight versions of the Seiko 200 and 500 Series of dot-matrix impact printers. This IC contains coding for 96 USASCII characters (upper and lower case), plus all the logic required to print up to 24 characters/line for the 200 Series and 40 characters/line for the 500 Series. The R6500/1 has both an RS-232C interface, which operates at up to 7200 baud, and a parallel Centronics interface.

Rockwell design engineer Leo Pardo says the R6500/1's program occupies less than 2k of the ROM and that the chip's 64 bytes of RAM are adequate to handle a 40-column printer. Discrete transistors drive the print solenoids; some additional gates provide timing control. Fewer parts are required if you use only the serial interface.

Another printer IC—the Motorola MC14415 CMOS quad precision timer/driver—aims at use in high-speed line printers and provides the critical timing for those units' hammer drivers. It contains four identical circuits, each consisting of input logic, divide-by-100 counters and output buffers. With a 15V supply, it sinks 7.8 mA of output current when operating at 25°C.

National Semiconductor's DS3654 printer-solenoid driver houses a serial-to-parallel 10-bit shift register with a clock and data input, a data output from the tenth bit and 10 open-collector clamped driver outputs. Each of these outputs sinks 250 mA and is internally clamped to ground to dissipate energy stored in inductive loads. This chip's major application is with serial μPs, such as National's COPS Series.

Advances in peripheral-driver ICs should also serve to reduce printer component count. Dale Pippenger, Texas Instruments' applications-

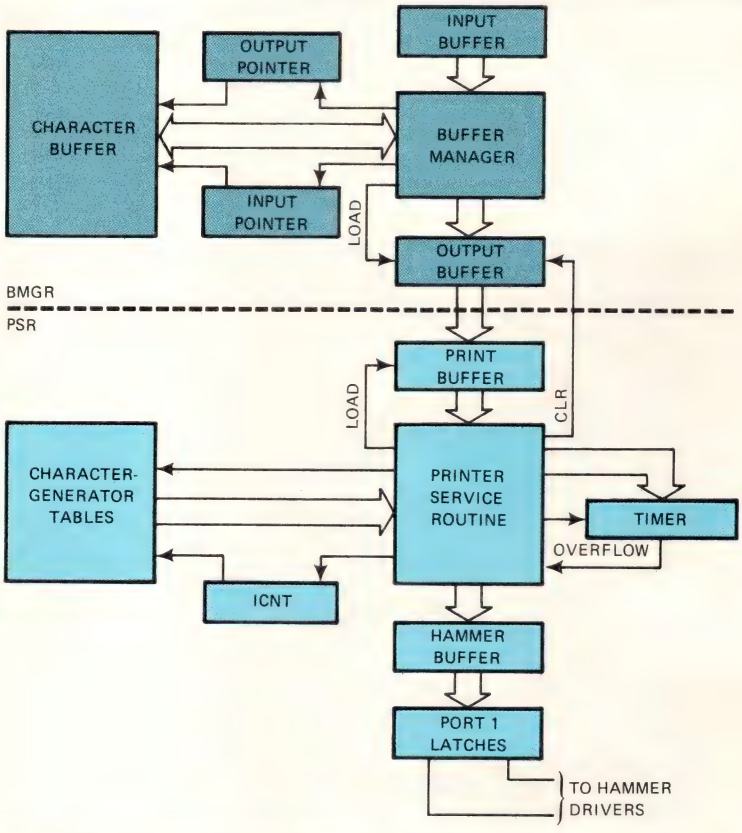
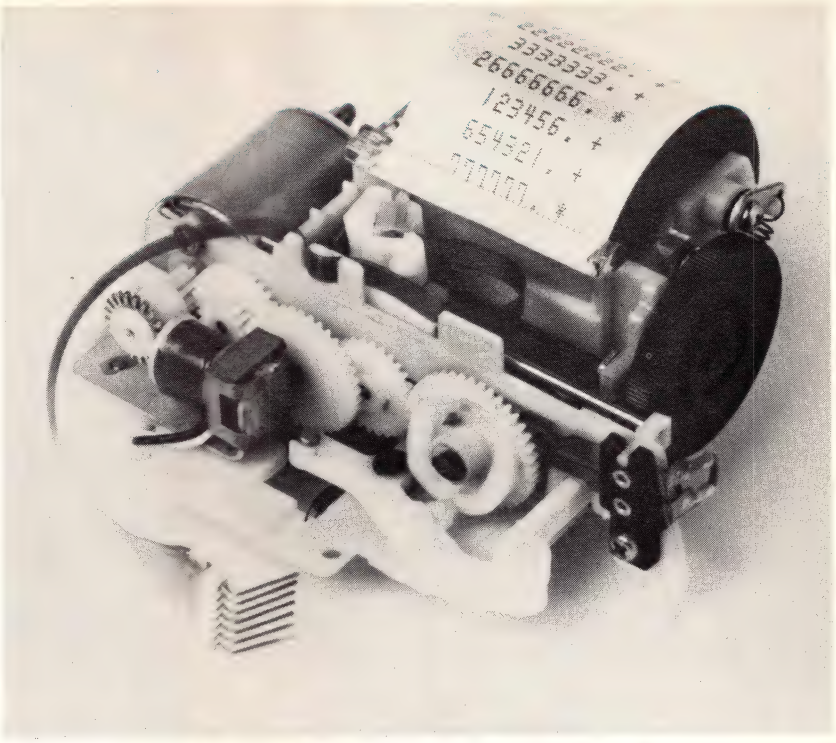


Fig 1—Software *for the Intel UPI-41 and the LRC printer it controls contains two main parts: a buffer manager (BMGR) and a printer-service routine (PSR).*

engineering manager for peripheral circuits, notes that one area of improvement lies in increasing these devices' power dissipation—TI's NE Series dissipates 2W, compared with 600 to 800 mW for older units. A heavier lead frame, using the middle three pins on each side of the DIP to connect to a heat sink and to ground, does the job.

A further improvement in peripheral drivers results from the use of pnp inputs, which exhibit a higher impedance, thereby allowing MOS and CMOS interfacing. Previously, npn inputs prevented configuring a direct interface to MOS devices.

Pippenger also points out that some of the newer peripheral drivers can also control motors. TI's SN75380, for example, serves this task, although it was designed as a bubble-memory driver.



TTL inputs *from a Fairchild 3257 or Signetics 2516 character generator go to a National Semiconductor DS8887/8897 octal high-voltage display driver and then to a Sprague ULN2002/2004 octal Darlington power driver; the resulting signals control the printhead electrodes in Hycom's DC-1206B, an electrosensitive nonimpact printer. Used in portable and hand-held applications, the printer produces up to 15 columns of 5× 7 dot-matrix characters.*

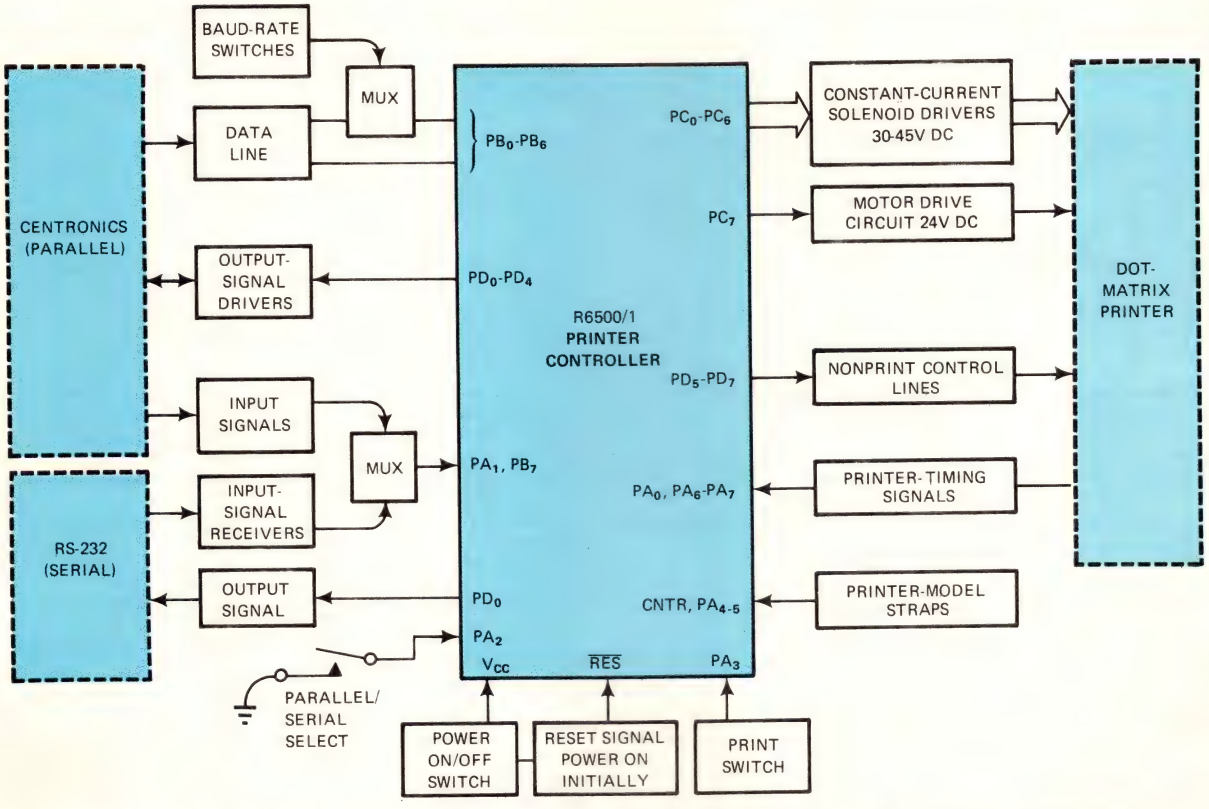


Fig 2—With both serial- and parallel-interface capability, *Rockwell's R6500/1 printer controller serves eight versions of Seiko's 200 and 500 Series units.*

Electrosensitive printouts stand up to heat, sun and moisture

plastic rotor. A slip-ring disc forms the head's rear structure and connects through flexible etched cables to the stylii. Inserted through the writing platen and formed into a 120° arc, paper is pushed through the unit continuously. Centrifugal force extends the stylus wires through slots in the printhead cover and into contact with the platen and paper as the head rotates. As the stylii move across the paper, applied electrical pulses produce 5×7 dot-matrix characters.

The original version of the printer produces 2200 cps; an improved unit will output 4400 cps. Scheduled for introduction this year, the improved unit will use 8-1/2-in.-wide paper, compared with the 4-in.-wide stock in the original unit. Finally, while the older model prints along the paper's length, the new one will print across its width.

Rounding out the list of nonimpact printer types, electrostatic units—initially used for plotting—have been adapted to high-speed printing as well. This printer type uses dot-producing stylii, arranged in either a single line of about 1000 or a 2-line staggered array of about 2000.

In operation, special paper is first passed across the stylii, which develop charged points on it. (In one approach, stylii are activated by addressing a group of 64 with a code identifying only the points that correspond to input data. Then the next 64 stylii are addressed, and so on. The cycle repeats for every line of data presented.) After the charged dot pattern is produced, the paper passes through a liquid toner and is dried, producing the required hard copy. Speeds up to 2400 lpm are possible with characters printed in a 5×7 or 7×9 dot matrix. Typical prices for electrostatic printers run in the $10,000 range for 1000-lpm units. Major suppliers include Versatec, Gould, Houston Instrument and Litton Datalog.

Interfacing and drive circuits

As you can see, you can choose among OEM printers spanning a wide range of technologies and prices. But whichever technology you decide

OEM-printer manufacturers

For more information on the products discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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RS-232 sports several variations—options and ambiguities can confuse

upon, you face the need to connect the chosen printer with a computer system through either a serial or parallel interface.

As John Leggat, manager of customer support for Centronics, points out, the simplest form of printer interface transmits data serially, generating no acknowledgement of the data's acceptability. "If you are willing to live with this shortcoming, your task is simple: A driver talks to the printer; all you must do is let the system drive and print. But things can happen to a message, particularly in the presence of noise or a power change. In systems at the opposite end of the serial-communications complexity spectrum, the driver deals with these problems by transmitting data and then asking if that data has been received properly before transmitting more data."

In serial communications, control and data signals usually come from one pair of lines; an additional line sometimes provides a busy signal—used to delay data transmission until the printer can handle that data. In parallel communications, on the other hand, seven or eight lines control computer/printer handshaking, which allows data to be sent to the printer at appropriate times.

The simplest serial mode is simplex—data goes to the printer with no acknowledgement to the driver. In half-duplex mode, the printer receives and the driver transmits, but not simultaneously. In full-duplex operation, printer and driver can both simultaneously receive and transmit.

The most widely used serial-communication standard is RS-232C. But, Leggat cautions, "this standard is not in itself enough to describe an interface. There are many possible variations—I suspect that I can identify more than 100 different versions used with our equipment. Options and ambiguities can confuse designers."

As Don Perkins, VP at interface manufacturer MDB Systems, Orange, CA, explains, one of the confusing areas in an RS-232C connection is the use of pin 2 for transmitted data and pin 3 for received data. The confusion arises in a simplex or half-duplex connection, where pin 2 at one end of the line must go to pin 3 at the other end, and vice versa; this pin transposition can be handled in the cable itself or at either connector. Another confusing aspect of the RS-232C standard is the pin used to indicate a busy condition. Sometimes pin 11—which is normally unassigned—has this task; in other cases pin 19 or pin 20—with the appropriate polarity—is used.

Many types of communication protocols serve RS-232C systems. One protocol uses USASCII code STX (start of text) to precede data and ETX (end of text) to follow data transmission. Another uses USASCII ACK to acknowledge message receipt and NAK to indicate no acknowledgement. This ACK/NAK combination usually serves polling computer configurations. STX, ETX, ACK and NAK are nonprinting characters.

In one version of RS-232C, transmitted data has one start bit, seven data bits, one parity bit (odd or even) and one or more stop bits. At the receiving end, the data is assembled into 8-bit characters (seven data bits and one parity bit), parity is checked and assembled characters go in parallel to the printer.

A serial-communication alternative to the voltage-level-dependent RS-232C, 20- or 60-mA current loop derives from Teletype communication and is still used by perhaps 20% of all printer systems. Here, sequences of ON/OFF mark-space current pulses in Baudot code are transmitted asynchronously in combinations of five ONEs and ZEROs, with each sequence preceded by a start element to ensure synchronization between the driver and receiver.

When current-loop or RS-232C communication occurs over telephone lines, a data set (modem) converts the signals to ac and back again to the appropriate current or voltage levels. The data set also provides a reverse channel to allow transmission of a signal that acknowledges receipt of a message. Other signals available with the data set include request to send and data terminal ready. Transposition of pins 2 and 3 is not required here, because the data set automatically performs this function. Many data sets allow transmission rates between 110 and 9600 baud.

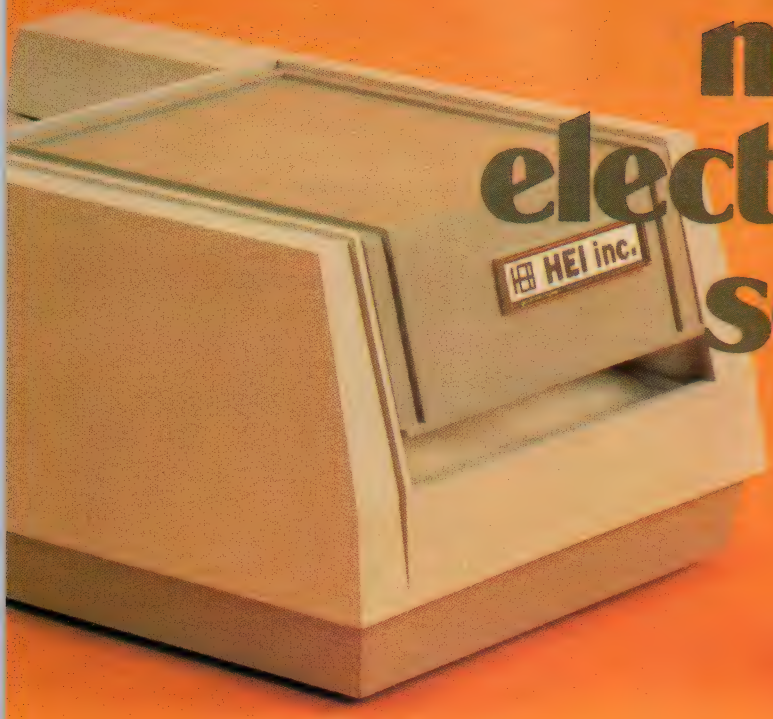
Meeting parallel-interface standards

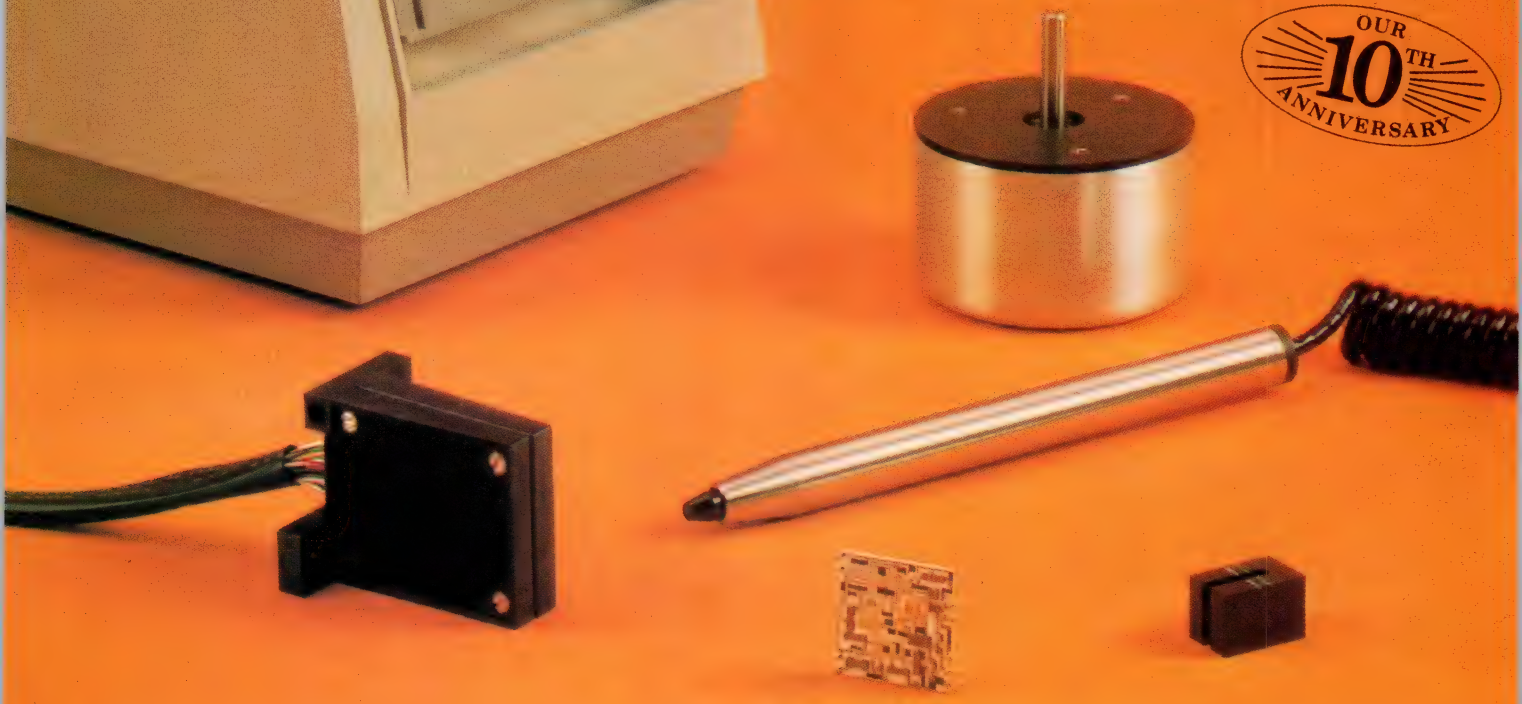
When connecting a printer to a computer, you can also choose to implement a parallel interface—usually faster than a serial one. But in that case you must really accommodate two parallel hookups. At the host-computer end, computer I/O and software reign; at the printer end, printer handshake protocol and signal timing are important. Many parallel computer interfaces exist, but the de facto standards in this area have been established by Centronics and Dataproducts.

Printer-controller parallel-interface boards are housed either in the printer or in card slots provided in the host computer. Most computer manufacturers, and about a half-dozen interface specialists, offer these cards, and in most cases it's more cost effective to buy rather than design them if the quantities you require are small.

"The parallel-interface problem is generally oversimplified," MDB's Perkins notes. "Many

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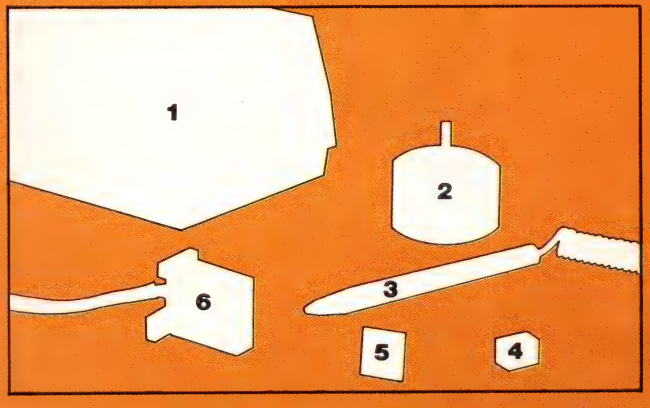
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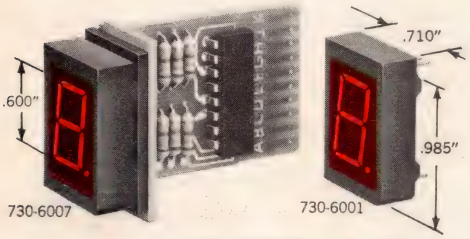
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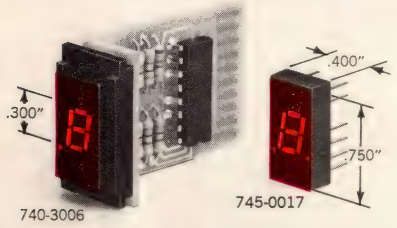


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Parallel interfaces follow two de facto standards

times a printer manufacturer will claim its printer is plug compatible with the Centronics or Dataproducts interface. That may be true electrically but not functionally, and implementing an interface could require adding circuitry to the printer-controller board." MDB provides boards that accommodate both interfaces.

The Centronics and Dataproducts interfaces, however, differ in several respects: In addition to using different connectors, they require different handshake signals. In the Dataproducts standard, the printer first generates a Ready signal, which tells the computer that all operating voltages are on, interlocks are closed, paper has been loaded and no printer faults exist. Then the printer produces an On Line signal, which indicates that it's ready to accept data. Next, a Demand line goes HIGH, requesting a character from the computer; it remains HIGH until the printer receives Data Strobe. After the data character is loaded into the printer, the Demand line goes LOW.

In the Centronics interface, $\overline{\text{Fault}}$ is used instead of Ready, and Select serves in place of On Line. Also, $\overline{\text{Acknowledge}}$ and $\overline{\text{Strobe}}$, with completely different timing, are used instead of Dataproducts' Demand and Strobe. **EDN**

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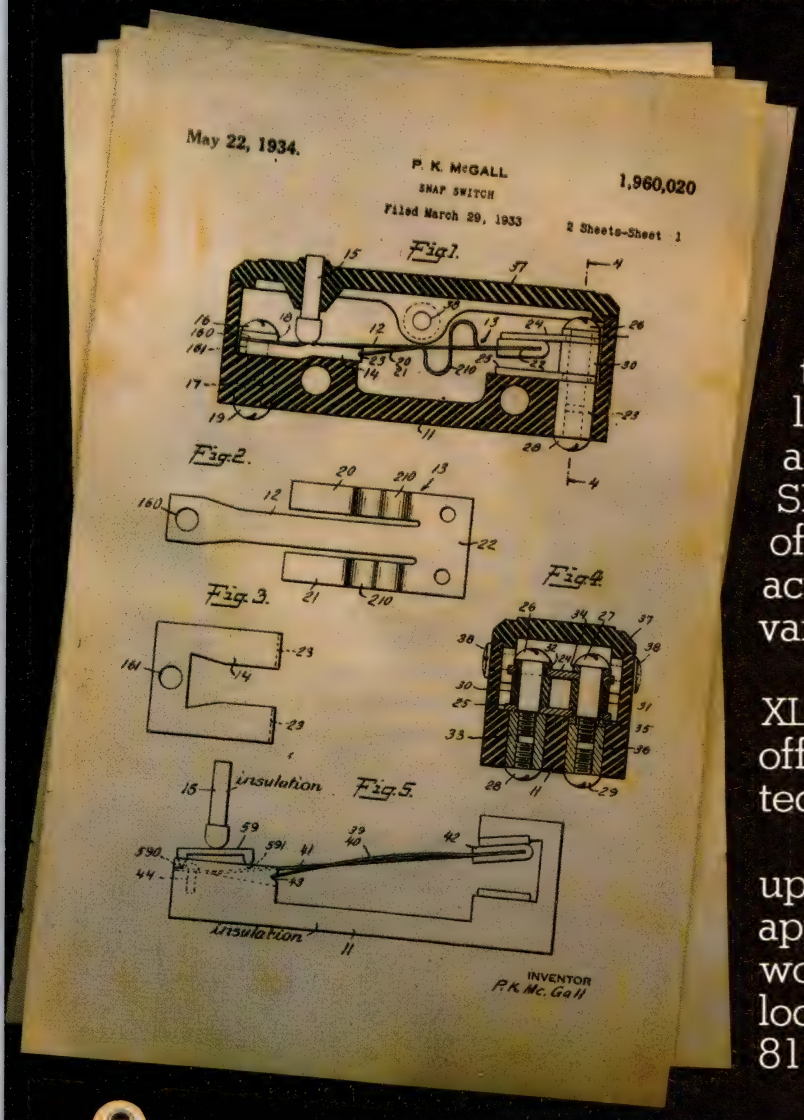
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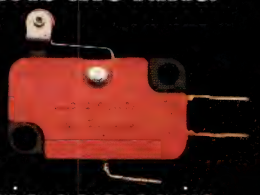
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May 22, 1934. P. K. McGALL SNAP SWITCH Filed March 29, 1933 1,960,020 2 Sheets-Sheet 1
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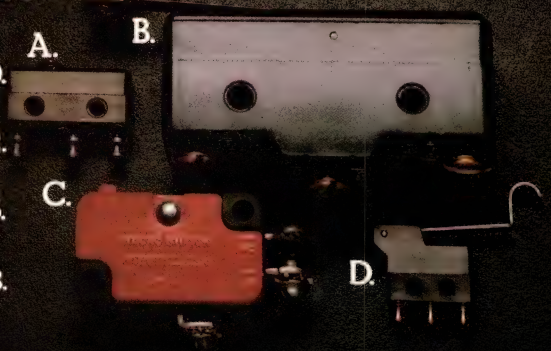


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Use your midrange μP equipment

Put off by the large investment required by 1-chip-μC development systems? Here's how you can use an up-and-running μP system to

Robert H Cushman, Special Features Editor

Although today's low-end 1-chip μCs promise the ultimate in price reduction once the products they're used in reach mass production, they often initially appear forbiddingly difficult and expensive to incorporate into those products. Why? Because designers feel discouraged by the apparent need to buy an expensive, specialized development system for each 1-chip-μC family they wish to investigate.

We, too, faced this problem. And our solution was to use some of our available moderate-cost, midrange μP equipment to develop a method for exercising the ROMless emulator versions that exist for most of today's low-end 1-chip μCs. Although to date we've only used an E&L Instruments 8080 system as a "host" computer and a National Semiconductor COP 400-family 402 ROMless emulator as a "target" 1-chip μC in this manner, we believe our method general enough to apply to the combination of any midrange μC or minicomputer host and any 1-chip emulator.

A slow-but-sure approach

In our setup (**Fig 1**), the E&L MMD-1's monitor loads COP 400-family instructions into an area of the 8080-system RAM. The 8080 then resets the 402 and turns control over to it. The 8080 system at that point becomes a "slave" to the 402: Each time the 402 sends out an address, the 8080 sends back the instruction code associated with that address.

The 8255 I/O chip in our setup provides the interface between the 8080 and 402. This chip's MODE 2 operation, which turns its port A into a bidirectional port, proves especially handy for this application.

The SMC 5016 in the configuration provides a programmable crystal-controlled clock for the

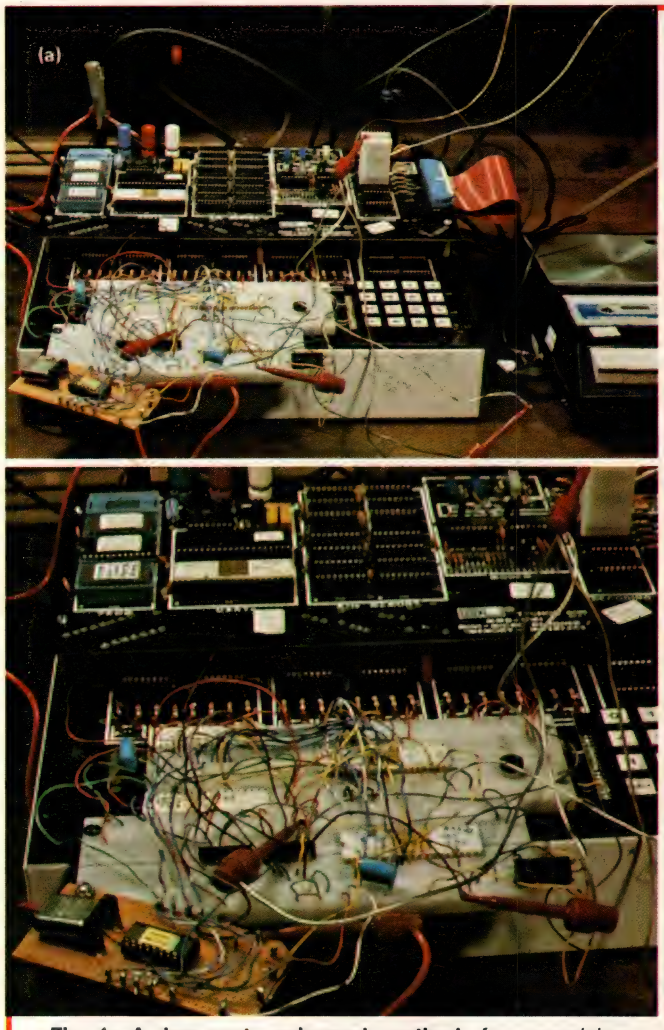
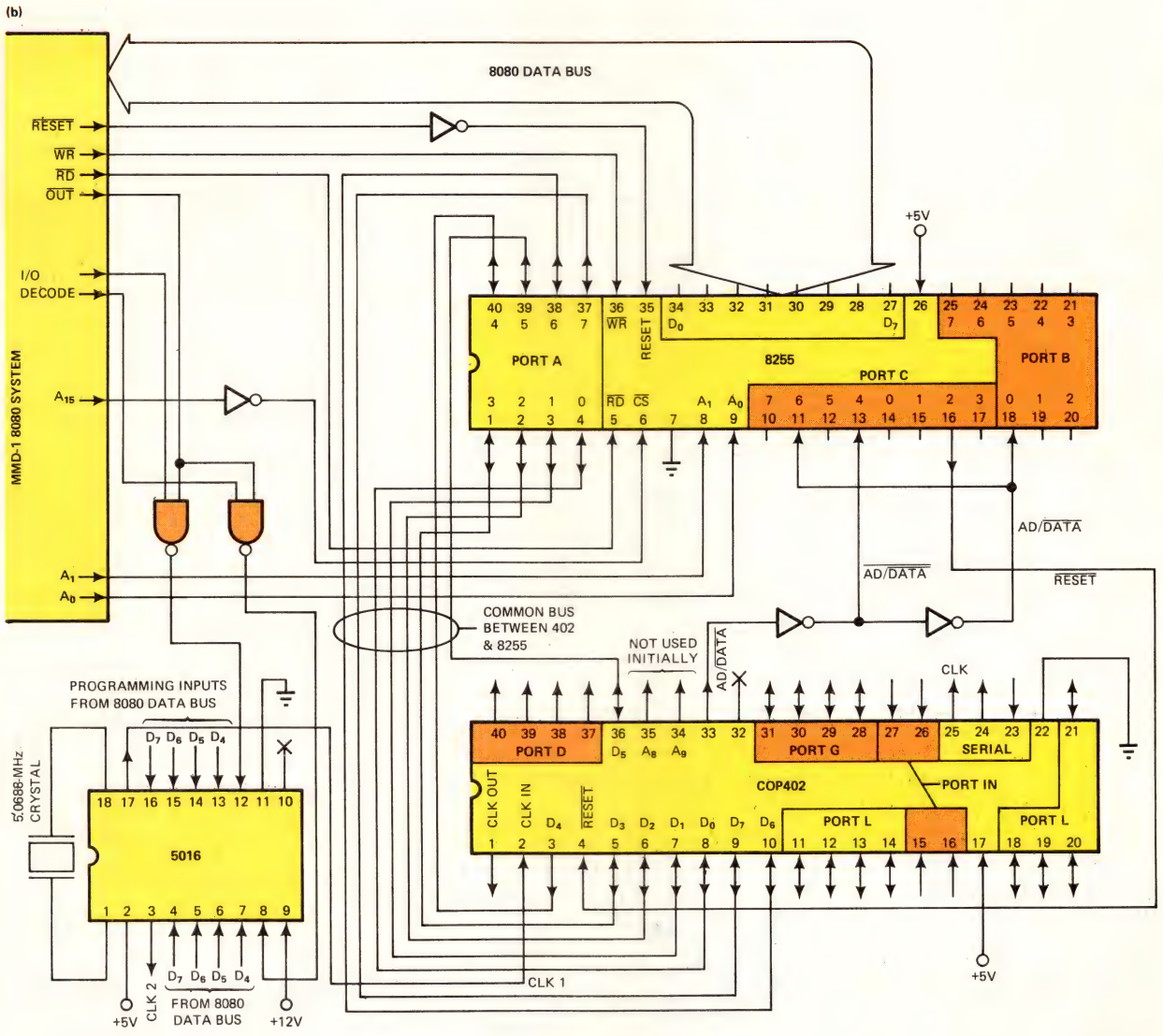


Fig 1—A low-cost, universal method *for exercising 1-chip μCs uses a small midrange μP system to act as both controller and program memory for the 1-chip device* ***(a)****. In EDN's setup, a moderate-cost (much less than $1000) E&L Instruments MMD-1 8080 system is the host, and a National Semiconductor COP 400-family 402 ROMless emulator device serves as the 1-chip μC. A programmable 8255 I/O chip acts as the interface between the 8080 and the 402, and a crystal-controlled SMC 5016 baud-rate generator provides a programmable clock input for the 402* ***(b)****.*

to explore today's 1-chip μCs

obtain a first-pass familiarity with today's 1-chip devices—for an expenditure far smaller than you might think necessary.



First-pass familiarity with a 1-chip μC costs about $500

402, and its second programmable channel can furnish synchronized inputs for examining the behavior of the 402's input ports (including the serial port) and testing that device's interrupt capability.

You can thus see that we use a roughly $500 system to approximate the more expensive ($4000 to $20,000) development systems sold by the 1-chip-μC suppliers. We don't claim, of course, that this system can replace the "official" setups, for it has some obvious shortcomings. But it is a sensible approach to gaining initial hands-on familiarity with the dozens of available 1-chip μCs, before you decide which one looks best for your application and buy the "official" system for it.

Living with lowered speed

The most glaring deficiency of our approach is that the 1-chip device must run slowly to give the host μC system time to execute all of its instructions. The MMD-1 system we use operates at a slowed-down 750-kHz system clock to allow use of

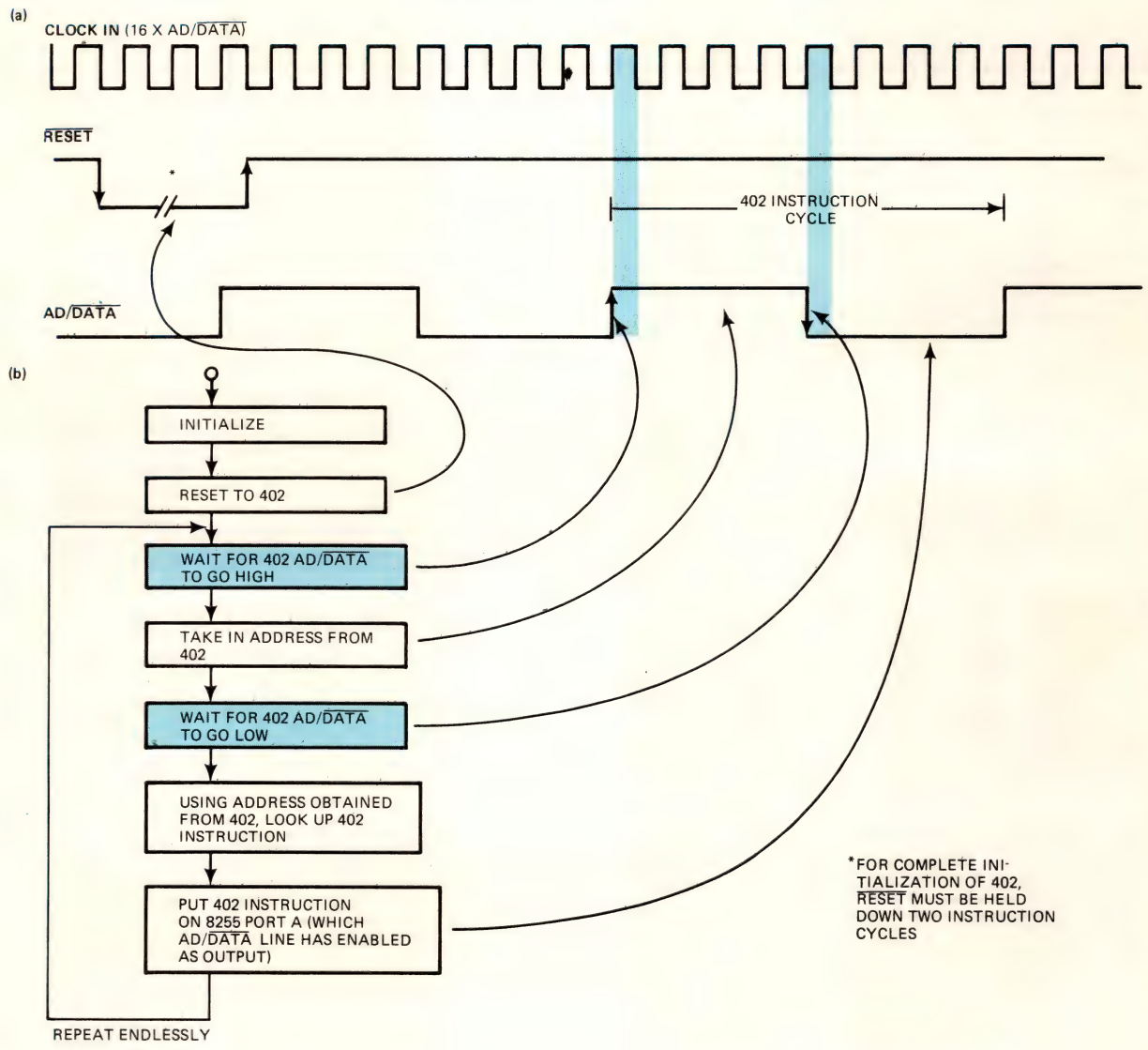


Fig 2—With very few signals *for effecting its external instruction fetch* ***(a)****, the COP 402 ROMless emulator nevertheless provides enough such signals for use by the 8080 host computer. The 402's AD/DATA output goes HIGH when the 402 sends out an address for an instruction and LOW when the 402 expects the instruction to come back. As the 8080-software flow diagram* ***(b)*** *shows, the 8080 prepares the 402 for a "run" by first holding down the 402's RESET input to force the 402 PC to all ZEROs, then releases that line to let the 402 start executing. Meanwhile, the 8080 switches from "master" to "slave" status and watches the 402's AD/DATA line so it knows when to accept addresses from the 402 and when to send back instruction code.*

slow 1702A PROMs; we thus had to program the 5016 baud-rate generator at 76.8 kHz to give the MMD-1 time to execute the roughly 12 instructions occurring during each half of the 402's fetch cycle. Therefore, the 402, which divides the incoming clock by 16, must operate at an approximately 5-kHz internal frequency—far below its normal specified range of 100 to 250 kHz.

We were sure the system could function at this reduced speed, but to double check we called COP 400-family designer Ralph Haines. He explained that the specified lower limit on the clock rate

```
ADDRESS LABEL  CODE (OCTAL)  MNEMON  OPERAND     COMMENTS
002 005 START    021          LXI,DE
    006          000                 CODE/       POINT 8080/DE
    007          030                 COP402      TO 402 CODE
    010 SET CLK  076          MVI,A               SET UP CLOCK-1
    011          060                 76.8K       FREQUENCY
    012          323          OUT
    013          003                 PORT 3
    014 SET CLK  076          MVI,A               SET UP CLOCK-2
    015          000                              FREQUENCY
    016          323          OUT
    017          004                 PORT 4
    020 SET I/O  076          MVI,A               SET 8255 PORT A
    021          302                 MODE 2      TO MODE 2 (BI-DIR)
    022          062          STA                 PORT B AS INPUT
    023          003                 8255/       PORT C0-C2 AS OUT.
    024          200                 CONTROL
    025          072          LDA                 LOOK AT PORT C
    026          002                 8255/       TO CHECK CONTROL
    027          200                 PORT C      STATUS

    030          323          OUT
    031          002                 PORT 2
    032          315          CALL
    033          200                 KEY A
    034          002
    035          041          LXI,HL              POINT 8080/HL
    036          000                 TRACE       TO TRACE BUFF.
    037          034                 BUFFER

    040          016          MVI,C               SET NO. 402 EXE-
    041          377                 # 402 E     CUTIONS ALLOWED.
    042          006          MVI,B               PUT IN BREAKPT
    043          007                 BRK ADD     ADDRESS.
    045          076          MVI,A               ENABLE 8255
    046          011                 SET C4      INTERRUPT IF
    047          062          STA                 NEEDED.
    050          003                 8255/
    051          200                 CONTROL
    052 RESET    076          MVI,A               SEND RESET TO 402
    053          004                 RSET C2
    054          062          STA
    055          003                 8255/
    056          200                 CONTROL
    057          072          LDA
    060          002                 8255/
    061          200                 PORT C
    062          323          OUT
    063          002                 PORT 2
    064          315          CALL
    065          220                 KEY B
    066          002
    070          076          MVI,A               LIFT 402 RESET
    071          005                 RSET C2
    072          062          STA
    073          003                 8255/
    074          200                 CONTROL
    075          303          JMP                 OPTIONAL JUMP
    076          300                 FETCH B     TO FETCH-B
    077          002

    100 FETCH A  072          LDA                 WAIT FOR 402
    101          002                 8255/       A/D LINE TO GO
    102          200                 PORT C      HIGH, AS INDI-
    103          346          ANI                 CATED BY 8255
    104          040                 C BIT/5     BIT C5.
    105          312          JZ
    106          100                 FETCH A
    107          002
    110          072          LDA                 8080 GETS ADDR
    111          000                  8255/      FROM 402 &
    112          200                 PORT A      READIES IT FOR
    113          137          MOV,EA              TABLE LOOKUP.
    114          067          STC
    115 A/D LO?  072          LDA                 WAIT FOR 402
    116          001                 8255/       A/D LINE TO
    117          200                 PORT B      GO LOW.
    120          037          RAR
    121          332          JC
    122          115                 A/D LO?
    123          002
    124          032          LDAX,DE             8080 SENDS 402
    125          062          STA                 CODE OUT TO
    126          000                  8255/      8255 PORT A
    127          200                 PORT A      FOR 402.
    130          303          JMP                 ENDLESS LOOP
    131          100                 FETCH A     OF 402 FETCHES.
    132          002

    140 BREAK    076          MVI,A               PUT OUT INDI-
    141          377                 ALL 1'S     CATION THAT
    142          323          OUT                 BRK REACHES
    143          000                 PORT 0      & STOP.
    144          166          HLT

    200 KEY A    315          CALL                TO HOLD 8080
    201          315                 KEX KEY     TILL OPERATOR
    202          000                             HITS KEY A.
    203          376          CPI
    204          015                 CODE/A
    205          302          JNZ
    206          200                 KEY A
    207          002
    210          311          RET
    220 KEY B    315          CALL                TO HOLD 8080
    221          315                 KEX KEY     TILL OPERATOR
    222          000                             HITS KEY B.
    223          376          CPI
    224          016                 CODE/B
    225          302          JNZ
    226          220                 KEY B
    227          002
    230          311          RET

    300 FETCH B  072          LDA                 WAIT FOR 402
    301          002                 8255/       A/D LINE TO GO
    302          200                 PORT C      HIGH, AS INDI-
    303          346          ANI                 CATED BY 8255
    304          040                 C BIT/5     BIT C5.
    305          312          JZ
    306          300                 FETCH B
    307          002
    310          072          LDA                 8080 GETS ADDR
    311          000                 8255/       FROM 402 &
    312          200                 PORT A      STORES IT IN
    313          167          MOV,MA              TRACE BUFF, &
    314          270          CMP,B               COMPARES IT TO
    315          312          JZ                  BREAK VALUE &
    316          140                  BREAK      READIES IT FOR
    317          002                             TABLE LOOKUP.
    320          137          MOV,EA
    321          067          STC
    322 A/D LO?  072          LDA                 WAIT FOR 402
    323          001                 8255/       A/D LINE TO
    324          200                 PORT B      GO LOW.
    325          037          RAR
    326          332          JC
    327          322                 A/D LO?
    330          002
    331          032          LDAX,DE             8080 SENDS 402
    332          062          STA                 CODE OUT TO
    333          000                 8255/       8255PORT A
    334          200                 PORT A      FOR 402.
    335          043          INX,HL              HOUSEKEEP HL
    336          015          DCR,C               PTR & C COUNT.
    337          302          JNZ                 ALL ALLOWED 402
    340          300                 FETCH B     EXECUTIONS DONE?
    341          002                             IF SO, FALL OUT.
    342          076          MVI,A               DISPLAY THAT
    343          377                 ALL 1'S     HAVE FALLEN OUT
    344          323          OUT                 ON PORT 1.
    345          001                 PORT 1
    346          166          HLT                 STOP 8080.
```

Fig 3—This program for 8080/402 interaction *runs on an MMD-1 system with the 402 connected as shown in* ***Fig 1.*** *The MMD-1 KEX monitor* ***(Ref 2)*** *sets up parameters in the initialization part of this listing (up to address 002 077), and KEX is also called at various points. The two fetch loops allow the 8080 to accept addresses from the 402 and send back instruction codes: FETCH A is a simple endless loop; FETCH B, a more elaborate loop with trace, breakpoint-detect and limit features. The user chooses between FETCH A and FETCH B by either leaving in the JMP at 002 075 or replacing it with NOPs. We assume that this program would be loaded into 8080-system RAM, so that all these changes could be made by the KEX monitor.*

FETCH B adds trace, breakpoint-detect and limit capabilities

ensures that the NMOS COP family's dynamic memory circuitry will operate reliably at the maximum specified temperature (70 to 85°C ambient). But he assured us that at room temperature, operating most COP devices down to, say, 1 kHz should pose no problem.

At this initial stage, we weren't concerned that our setup wasn't operating in real time, for our prime objective was being able to try out the 402 instructions and sample programs. The 1-chip-μC architectures are all sufficiently distinct and "tricky" enough to require that you really have a working system at your disposal to gain familiarity with the devices.

Explaining the 8080/402 interaction

Fig 2 outlines the 402 signals with which the 8080 must interact and the 8080 software that implements this interaction. Note that the COP 400-family devices have no halt or hold capability, either in software or hardware; the parts just keep running continuously. Looking at the AD/$\overline{\text{DATA}}$ control output from the 402 (pin 33), for example, you see that the 402 continually goes through instruction-fetch cycles. There's no way to stop this action—even the $\overline{\text{RESET}}$ input to the 402 (pin 4) only jams ZEROs into the 402 PC; it doesn't stop the fetch cycles.

Now consider the bidirectional port into which the 402 first puts out the instruction address (from the 402 PC) when the AD/$\overline{\text{DATA}}$ line is HIGH, then reads back the instruction or data when that line is LOW. The address continually increments (except when $\overline{\text{RESET}}$ forces the 402 PC to put out all ZEROs). Thus, any external computer such as our MMD-1 can control the 402 in only a few ways:

- Control the frequency of the clock input to the 402 (pin 2)
- Hold the 402 $\overline{\text{RESET}}$ line (pin 4) down, thereby continually resetting the PC and causing it to send out a stream of ZERO addresses
- "Fool" the 402 by sending back not the instruction codes that its PC has addressed, but rather a sequence that the 8080 wishes to "force-feed" the 402
- In conjunction with such force-fed code, program the 402 ports as inputs and externally feed desired conditions to those inputs.

We used the first two options to implement our basic fetch/execute cycle—FETCH A—described in the **Fig 3** software listing (octal addresses 002 100 to 002 132). We incorporated the other two options in the more elaborate FETCH B cycle, also shown in **Fig 3.**

Fig 3's software starts with initializations, which set up the 8080 to play its role of serving as a master controller and program-ROM simulator for the 402; the initializations include the setups for both fetch cycles. This software also programs the clock.

FETCH A is the simplest loop we could produce for the 8080's interaction with the 402. It uses 8080 wait loops to synchronize the 8080 with the 402's AD/$\overline{\text{DATA}}$ line. After the 8080 sees that line go HIGH, it accepts the PC address put out by the 402. (On our initial setup, we ignored the two high-address lines put out by the 402, because we felt our initial get-acquainted programs for the 402 would not exceed 256 bytes in length.) Then the 8080 waits for the AD/$\overline{\text{DATA}}$ line to go LOW, whereupon it looks up the instruction byte indicated by the address just received from the 402. The 8080's indirect-address instruction, LDAX, proves handy for this look-up operation; as the listing shows, it's only necessary to store the address received from the 402 in the 8080's DE register pair, then use LDAX (DE) to fetch the 402 instruction. After outputting the instruction to the I/O port, where the 402 can access it, the 8080 program loops itself back for another

```
TRIAL CODE FOR 402, #1

000 402-1    000 CLRA     CLEAR A
001          123 AISC     ADD 3 TO A
002          120 CAB      A TO BD
003          063 OBD      BD TO PORT D
004          076
005 HALT     305 JP       HALT


TRIAL CODE FOR 402, #2

100 402-2    000 CLRA     CLEAR A
101 START    063 OGI      PUT "3"
102          125          OUT
103 DELAY-1  121 AISC     COUNT
104          303 JP       DELAY-1
105          063 OGI      PUT "2"
106          122          OUT
107 DELAY-2  121 AISC     COUNT
110          307 JP       DELAY-2
111          301 JP       START
```

Fig 4—Check out these examples *of trial 402 programs, which can be used to both verify the operation of the 8080/402 system and gain familiarity with the COP 400 1-chip-μC family. The first program loads an immediate value into one of the 402's internal registers and outputs it to a 402 port where it can be examined; this program ends with a pseudo-halt loop. The second program puts out a continuous square wave on one of the pins of a 402 port, using 402 delay countdowns to make the square wave slower than required for normal 402 operation.*

FETCH A cycle. In this manner, FETCH A keeps delivering instructions to the 402, and it's up to the person who writes the 402 program to put a halt loop at the end of that program if it's important that the 402 not run wild.

Fig 4 shows examples of the short 402 programs we used to check whether our setup was functioning properly. We'd start out with the CLRA (clear accumulator) stipulated by National in the COP manuals (Haines said he uses that instruction to clear COP 400 ports), then perhaps use a load-immediate instruction to put known data into one of the 402 registers, then follow that instruction with one to output the known data to one of the 402 ports where we could see it. Usually, we'd end this sort of program with a short jump (JP) to prevent continued 402 operation. This final loop could also be used to view the system signals on a scope.

The hardware/software combination described here works, but we have not had the time to thoroughly examine how faithfully it carries out the details of the desired 8080/402 interaction. Also, we are not sure that the configuration shown takes full advantage of the available 8255 port C handshaking lines when the 8255 port A uses the MODE 2 (bidirectional) option. Also remaining to be checked are timing limitations—among the time intervals required by the host computer to execute its instructions in the fetch cycle and the slowest clock speed at which several sample 402 devices operate reliably over a typical range of lab ambient temperatures. (Haines had indicated that this clock speed varies among devices.)

Adding features with software

The FETCH B option adds a trace of the 402 instruction addresses, a breakpoint detect and a limit to the number of instructions the 402 is allowed to fetch. These features prove desirable during application development, but they do lengthen the fetch loop and might necessitate running the 402 still slower (by reprogramming the baud-rate generator during initialization).

The 402 trace is accomplished by making the 8080 sequentially store all the addresses it receives from the 402 in a block of 8080-system RAM (chosen during initialization at line 002 035). These addresses can then later be reviewed and used to analyze the 402's behavior in executing a particular program. Such a trace is handy when you're trying to track down mysterious 402 behavior, for example, in a program that contains many jumps to subroutines and responses to interrupts. It also proves handy for checking that the 8080 and 402 interact properly. You can make the trace as long as the available 8080-system RAM permits.

The breakpoint detect we show in **Fig 3** compares each address from the 402 with a preset address previously loaded into 8080 register B during initialization at line 002 042. If the 402 sends an address that matches, the 8080 jumps to a breakpoint-service routine—BREAK—at location 002 140. This routine merely indicates on the 8080-system display that the breakpoint has been reached; it doesn't stop the 402. It probably would be a better procedure, however, if the breakpoint-service routine put the 8080 into another fetch loop, say "FETCH C," which would force-feed a sequence of instructions back to the 402 and cause that device to dump the state of its internal registers to one of its I/O ports. There, the 8080 could capture and hold them for analysis.

As Haines explained, it should be possible by this method to gain access to the contents of all of the 402's registers, except the addresses saved in the subroutine-and-interrupt stack and the states described in the internal EN control register. This is exactly the procedure National's Bernie Kute uses in the firm's COP development system.

A bipolar μP for real time

As a next stage in our exploration of this type of 1-chip-μC development system, we are contemplating replacing the 8080 with a Signetics 8X300 bipolar μP. We have one of Signetics' low-cost ($175) KT100SK boards for the 8X300, and it appears to have the necessary features, including bidirectional I/O ports. Most significantly, it has the speed to exercise 1-chip-μC emulators like the COP 402 at their full clock rates for real-time prototyping: The 8X300 can accept I/O data, manipulate it and send it out again in one 250-nsec cycle.

With a fast μP like the 8X300, you should be able to run short FETCH A-type loops in real time and longer FETCH B-type loops at close to real time, because low-end single-chip μCs aren't particularly fast—they don't have to be. Although many of the COP 400-family devices can operate with 4-μsec instruction cycles, in some designs they might run at only 16 μsec. In fact, the fastest instruction cycle specified for the family's low-power NMOS versions and ultra low-power CMOS versions *is* only 16 μsec—a figure that should give the 8X300 all the time it would need to interface with the 402.

Controller design on the way

In our next article, we'll show how the 402 can serve as a general-purpose industrial controller, either by itself (with a PROM for the program memory) or as a slave to a midrange μP such as the 8080 (in which case we'll use Mostek's MK4118 1k×8 RAM or Intel's 8185 1k×8 unit as a downloaded program memory). Unlike most 1-

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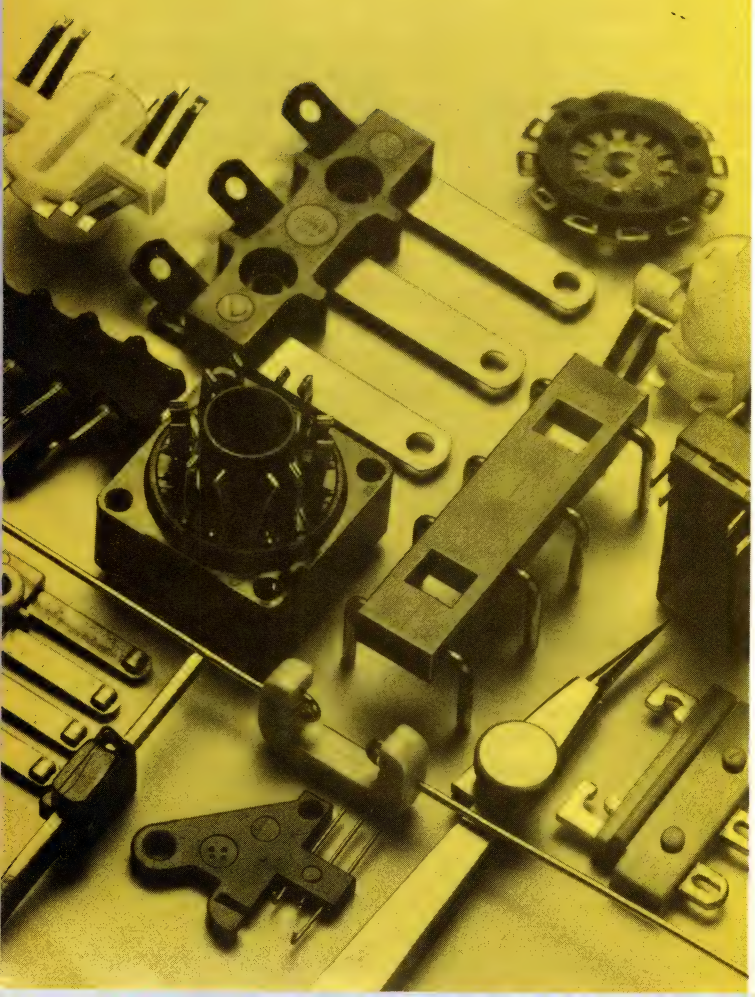
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A bipolar host could allow real-time operation of the target μC

chip-μC emulator parts, the 402 has a reasonable price tag (it costs just $7.50 in single quantity), so the systems we'll discuss will be practical for both actual short-run production and as prototypes for mass-produced, true 1-chip μCs with on-board ROM. **EDN**

Acknowledgement

The following members of the National Semiconductor COP 400 team provided assistance with this article: Hank Skawinski (marketing director), Tom Harper (marketing), Jack Irwin (applications), Bernie Kute (development system), Fred Horne (engineering director) and Ralph Haines (designer).

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2. Cushman, Robert H, "Interactively intelligent systems require an extra effort," *EDN*, August 5, 1978, pg 58. Contains a listing of the E&L KEX routine, which incorporates some of the subroutines called in the present article's program.

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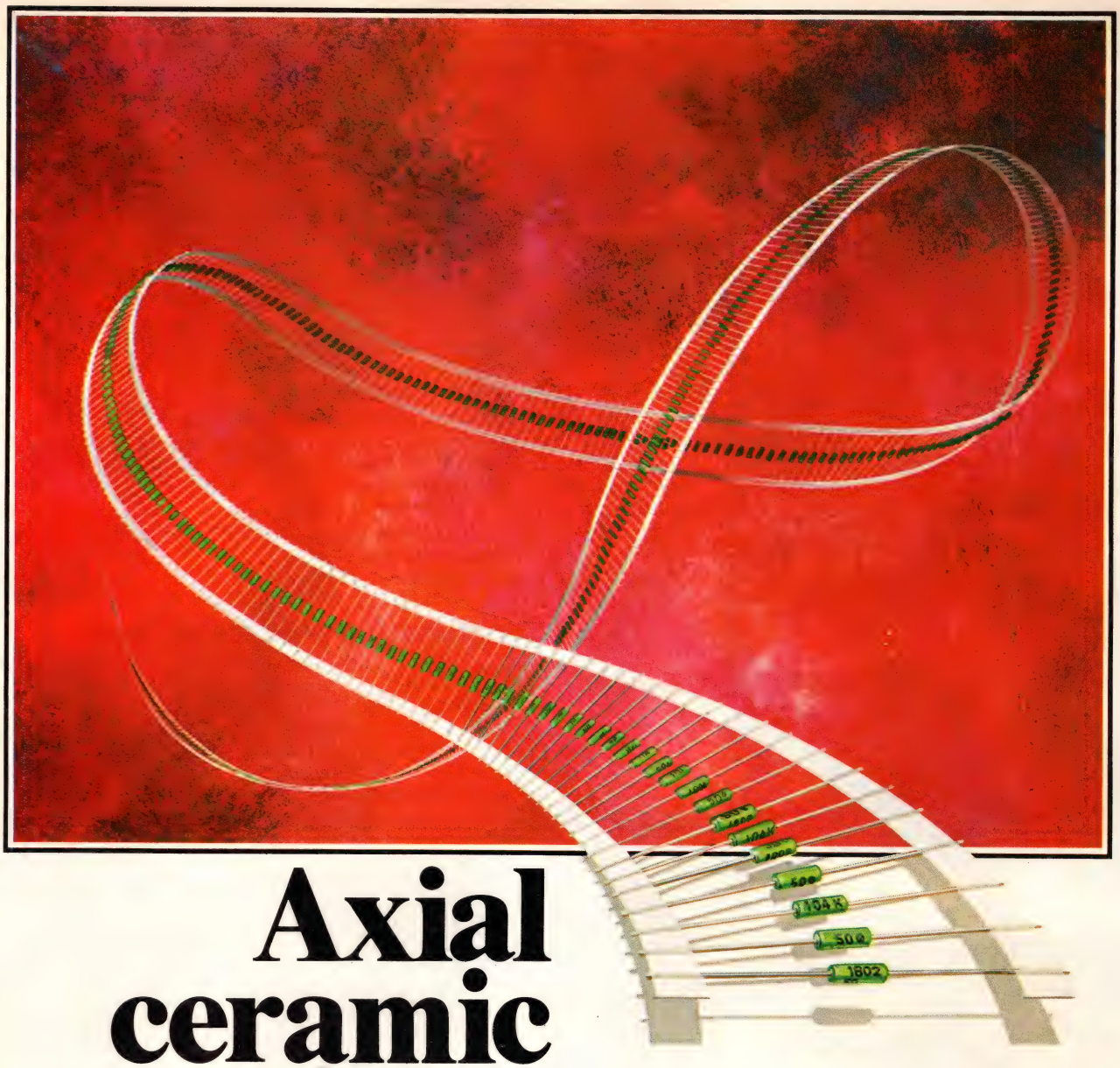
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Improved unity-gain follower delivers fast, stable response

Although unity-gain followers have served as buffers for some time, the problems associated with driving high-capacitance loads still plague designers. Here's a simple solution to stability and speed limitations.

Robert A Pease, National Semiconductor Corp

Heavy load capacitance can cause the output of a unity-gain follower—an operational amplifier with direct feedback to the inverting input (**Fig 1**)—to ring and oscillate. The LM110 follower, for example, normally drives a 50-pF load without problems, but it does not drive 500 pF stably—high capacitance significantly modifies the open-loop output impedance, reducing the phase margin to zero and causing oscillation.

You can easily eliminate such instability problems by adding a capacitor and resistor in series across the op amp's inverting and noninverting inputs. This solution can also greatly improve a follower's slew rate.

Analyze the problem

In general, increasing the ac noise gain of an op amp's feedback network improves capacitive-load tolerance. A common gain-increasing strategy adds $R_2 \approx R_F/10$ to the circuit shown in **Fig 2.** (A moderate-value capacitor, C_2, usually inserted in series with R_2, prevents the dc noise gain from also increasing and degrading dc-offset, drift and accuracy specifications.)

If the op amp has a 1-MHz gain-bandwidth product and $R_1=R_F$, the closed-loop frequency response will be 500 kHz. Inserting $R_2=R_F/10$ drops this frequency response to 90 kHz, where the amplifier usually tolerates a much larger capacitive load. AC noise gain equals $(R_F/R_1)+(R_F/R_2)+1$, and dc noise gain is $(R_F/R_1)+1$.

You can also increase ac noise gain by installing R_3 and C_3 instead of R_2 and C_2. The resulting value is

$$[1+(R_F/R_1)][(R_+ +R_3)/R_3]+(R_F/R_3).$$

In the simplest case, R_1 forms an open circuit, and ac noise gain equals

$$(R_+/R_3)+(R_F/R_3)+1.$$

Therefore, you can raise ac noise gain by using a low value for R_3 and a high value for R_+ and/or R_F.

The solution follows

For the particular case of a unity-gain follower, R_F is normally 0Ω as shown in **Fig 3.** According to the foregoing general analysis, if the value of R_S is low, ac noise gain is $(R_4/R_5)+1$, so you can increase ac noise gain—and therefore stability—by adding a large R_4 and a small R_5. (A large and constant R_S can make R_4 unnecessary; ac noise

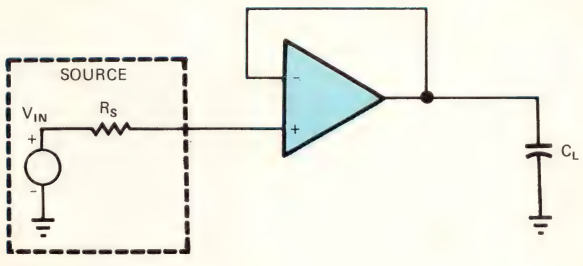


Fig 1—A unity-gain follower *driving a capacitive load can have stability problems.*

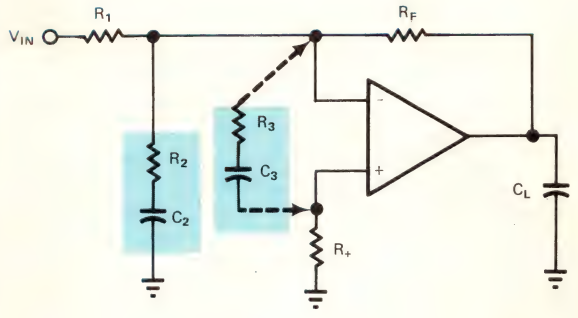


Fig 2—Compare two methods *of stabilizing an operational amplifier: Add R_2 and C_2 or R_3 and C_3.*

Adding a series capacitor and resistor improves stability

gain is then $(R_S/R_5)+1$.)

With LM110/LM310s, for example, 10k is an appropriate value for R_4. Using R_5=3.3k and C_5=200 pF, the LM110 stably drives capacitive loads up to 600 pF.

Technique speeds followers

You can also wire the resistor/capacitor combination across an op amp's inputs to increase the follower's slew rate. For example, an LF357 op amp's decompensation with a small internal capacitor normally requires gains higher than five to maintain stability (**Fig 4**). But the LF357 fits unity-gain-follower applications as easily as the LF356 (which is identical to the 357 except for the 356's internal compensation) and achieves better results. When source resistance is less than 1k, both the LF357 and 356 provide fast, stable responses, but the 357 has a 50V/μsec slew rate (typical) compared with 12V/μsec for a 356.

The LM349 decompensated quad op amp furnishes a bipolar input stage with a finite bias current (200 nA max). For best results in this application, add the resistor that controls the noise gain equally to the inverting and noninverting inputs as shown in **Fig 5**. With this circuit, the LM349 can slew at 2V/μsec typ and handles audio signals much faster—and without distortion—than the compensated LM348 (which, at 0.5V/μsec, slews only as fast as the general-purpose LM741). You can use the same approach for an LM101 by employing a 5-pF damping capacitor.

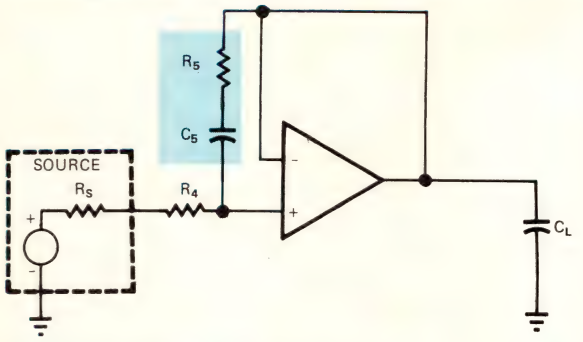


Fig 3—Stabilizing a unity-gain follower *for a capacitive load is simple. (The R_3 and C_3 of* ***Fig 2*** *are shown here as R_5 and C_5.)*

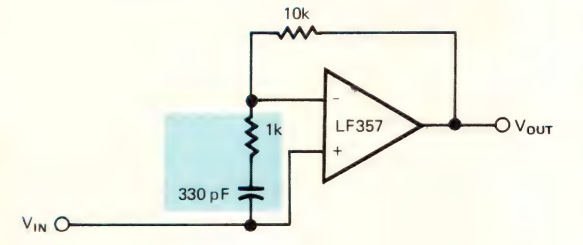


Fig 4—A unity-gain follower with fast slew rate *results from stabilizing an LF357 decompensated op amp by raising noise gain.*

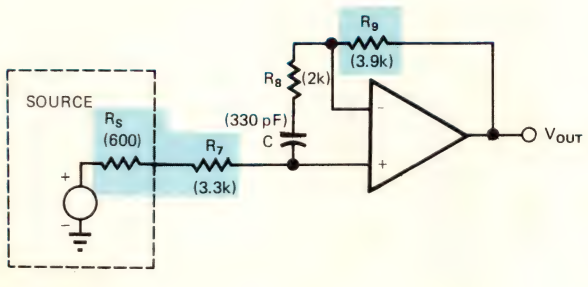


Fig 5—A fast follower *employs balanced resistors: $R_S+R_7=R_9$.*

Watch for problems

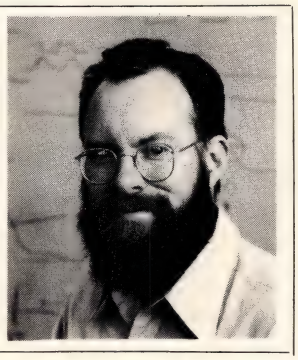
While inserting a resistor/capacitor combination across the inputs gives faster slewing, the circuit's bandwidth could degrade if source impedance (R_S) increases. In addition to guarding against bandwidth problems, make sure ac noise doesn't reach an objectionable level when you raise ac noise gain. Although most modern op amps exhibit low noise, raising that noise gain to 10 can significantly increase output noise.

If the series capacitor across the op amp's inputs is larger than necessary for stability and high slew-rate purposes, noise increases unnecessarily. In general, choose the minimum capacitance for the circuit in **Fig 3** according to the following formula (where f_v=op amp's unity-gain bandwidth):

$C_5\text{min}=4[1+(R_4/R_S)]/2\pi R_5 f_v=(R_4+R_5)/(\pi/2)f_v(R_5)^2$.

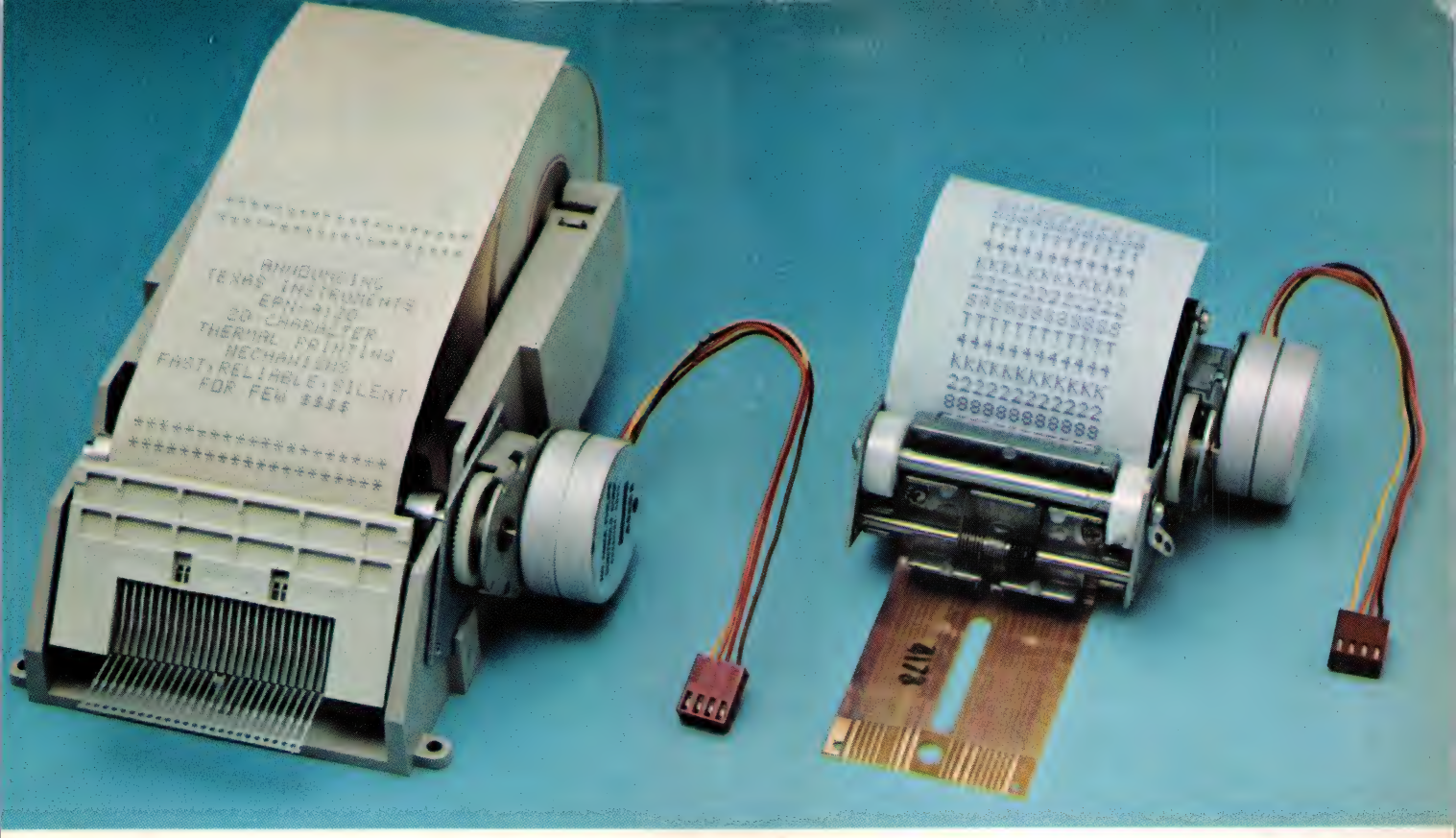
To allow for tolerance variations, make C_5's circuit value two or three times C_5min. **EDN**

Author's biography



Bob Pease is a staff scientist in the Advanced Linear Integrated Circuit Group at National Semiconductor Corp, Santa Clara, CA. Holder of four patents, he earned a BSEE from MIT. Bob lists tracking abandoned railroad roadbeds and designing V/F converters among his hobbies.

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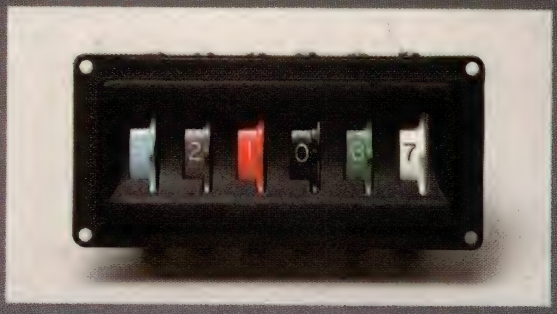
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Efficient and effective μC testing requires careful preplanning

You might be surprised to find that creating testable microcomputers requires less design effort than configuring their random-logic equivalents.

Edward S Donn and **Michael D Lippman,**
Fluke Trendar Corp

μC testing, like μC designing, can be very confusing until you examine the partitioning between *component, module* and *system* testing; the use of LSI has thoroughly blurred the differences between these test categories. Test engineers must now ask whether they should use system-test techniques on boards and components, or whether component-test techniques can function at the system level. It's even appropriate to ask whether or not it would be best to start from scratch and develop special algorithms for testing μCs. Add the question of how to achieve compatibility among testing in the lab, in production settings and in the field, and you really have a puzzle.

To get some useful answers, this article will review the established techniques available in production testing to see how well they can be applied to μCs. Then it will examine and discuss some of the merits of system testing vs circuit testing. Finally, it will focus on self test—a technique particularly suited to μCs.

Testing: the sword overhead

Microcomputers present very complex debugging problems—and so require dedicated, simple solutions. Attempting to find flexible, general-purpose approaches to μC debugging that also apply to random logic only compounds the complexity instead of solving the problem.

Furthermore, recourse to conventional troubleshooting tools and techniques can prove ineffective. A scope, for example, while useful for troubleshooting amplifiers, can't always serve to troubleshoot a μC in the lab, where a development system is called for. And if you try to use a development system in a production setting—when you really need a production tester with automatic-diagnosis capability—production will stop while the technicians try desperately to become computer scientists.

Microcomputers make timing and noise-margin considerations especially important because they contain complex switching circuitry and have narrow internal spec ranges. If μC-based designs reach the production stage with such timing or noise problems still evident, they can defy the diagnostic algorithms of even the

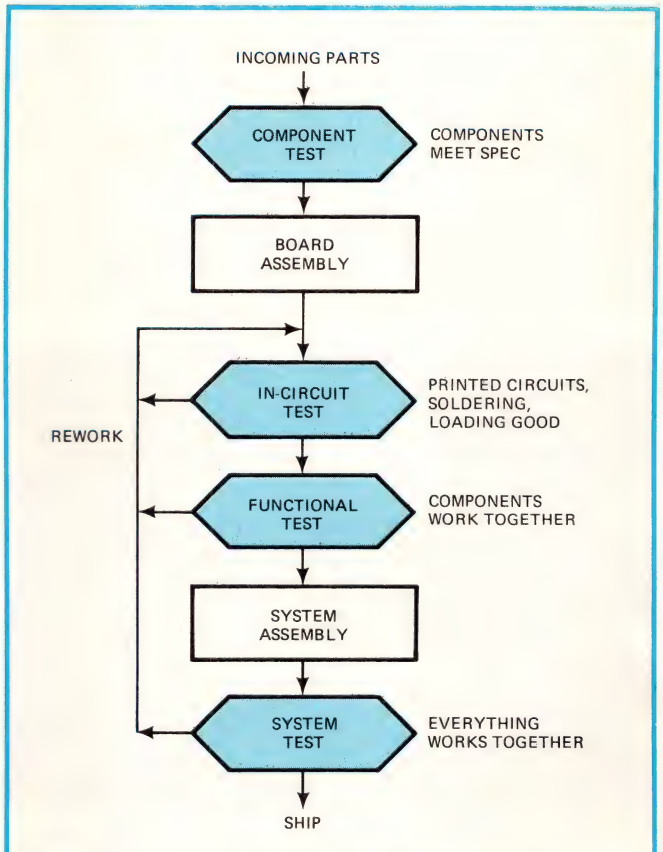


Fig 1—Production testing *follows this sequence.*

Intensive component and board testing saves system-level grief

best automatic testers and might require manual troubleshooting with a scope. But once problems of this sort have been eliminated in the lab, subsequent production testing seldom requires tools such as development systems and logic-state analyzers.

Production testing divides into four major groups: *component, in-circuit, functional* and *system.* Component testing serves to verify logic function, dc parameters and timing performance; in-circuit testing checks out interconnections, parts placement and parts function; functional testing verifies an assembled board's logic functions; and system testing assesses the logic functions of the entire circuit-board ensemble (system). Generally, the production-test sequence follows the pattern diagrammed in **Fig 1.**

Component testing: nipping trouble in the bud

The basic reason for performing intensive component-level testing is that achieving this level of control becomes unfeasible at the circuit-board or system level. And at those stages, marginal components readily foil the diagnostic algorithms of higher level testers.

Looking at the component manufacturer's test costs, it's easy to see why you can't expect 100% yield on incoming parts. After all, 1 sec of testing per device represents just about the maximum practical time the manufacturer can afford in high-volume production, yet for your use a part might require more like 15 to 30 sec of exhaustive tests.

A recently introduced component tester, the Megatest Q8000 (**Refs 1, 2**), lets you evaluate LSI or VLSI devices in the manner in which they operate in your system. By enlisting as a functional reference a device identical to the one under test and using a special pipeline technique to measure analog parameters, this tester lets you run 10-MHz patterns at a cost an order of magnitude lower than possible with stored-program testers. Such real-time testing both increases throughput by an order of magnitude and proves effective in finding speed and pattern-sensitivity problems.

Components OK, but does the circuit operate?

When component problems have been eliminated by testing, the next set of glitches will probably appear as "process" errors: open printed-circuit traces, solder shorts or misloaded (or missing) components.

In-circuit testers locate such problems by contacting all of a board's circuit nodes with a fixture of precisely located, spring-loaded pins (usually dubbed a "bed of nails"). A relay matrix selects sets of two, three or four nodes for reading by automated instruments, which in turn use a small voltage stimulus to identify opens, shorts or incorrect resistances and/or impedances.

Process errors constitute 50 to 70% of total system faults, so in-circuit testing can identify many problems at once. Often, in fact, this testing stage can list all the circuit faults—both analog and digital—in one pass, thus speeding up the functional testing that follows by removing many simple faults.

Programming in-circuit testers requires little effort, for it consists of entering—manually or automatically—topological files from known good boards. The most difficult task associated with an in-circuit tester is fabricating and maintaining its bed of nails. This fixture's hundreds of precision pins and connections, plus the pneumatic holding setup, provide many chances for contact problems. Then, too, each board type must have its own fixture, which

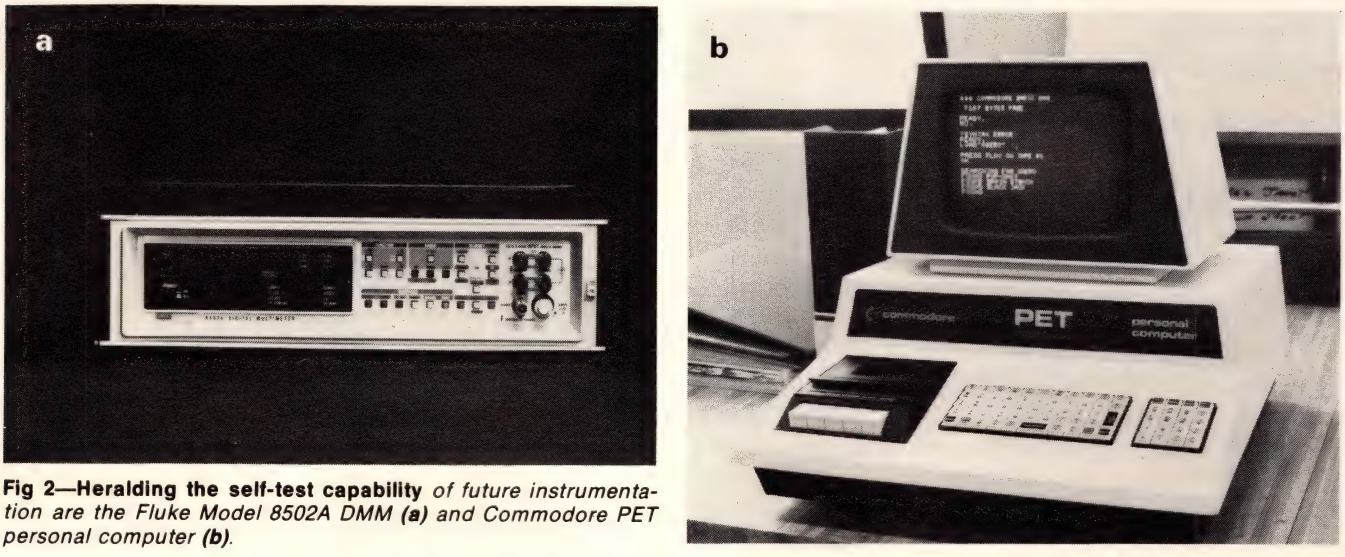


Fig 2—Heralding the self-test capability *of future instrumentation are the Fluke Model 8502A DMM* ***(a)*** *and Commodore PET personal computer* ***(b).***

must be revised for every board change.

Useful and effective in-circuit testing requires compromises—among them the need for elemental function tests to permit the checking of digital components for loading and function. μCs, with their bused dynamic LSI, can quickly confound an in-circuit test's inherent simplicity.

Functional testing proves a product works

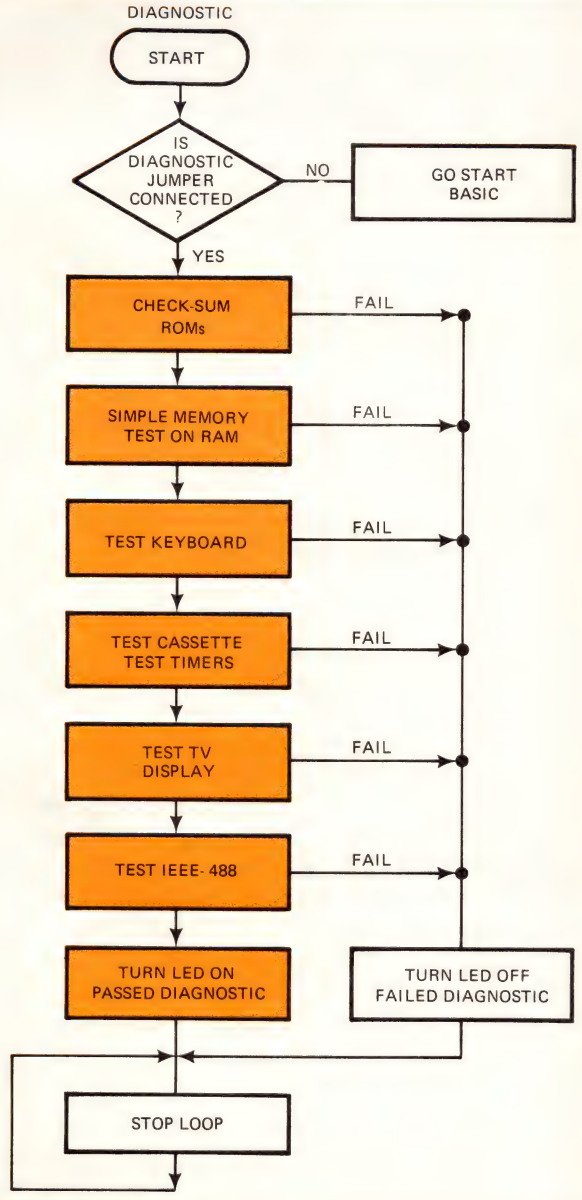
The quantum jump in integration provided by LSI makes functional testing of new μC boards similar to system tests performed on computers a few years ago. An added requirement calls for accurate diagnostics that can work when all components (which represent circuitry that formerly occupied whole boards) are soldered into place and working at their normal rated speed.

You can't elect to check the components in an isolated manner via sockets or electronic switching, because a functional test requires diagnosing faults in the *connected* ensemble. Neither can you check the ensemble by slowly stepping the system clock, for the most important faults are caused by high-speed system functions; dynamic LSI components won't even function at low speeds. It's thus not surprising that while only 10 to 30% of a μC-based system's total faults fall into the functional category, finding them can account for 50% or more of the total testing and repair costs.

Theoretical or pragmatic functional tests?

The high level of μC integration requires not only an improvement in diagnostic algorithms for functional tests, but also a choice between testing for theoretical performance and for the application (**Ref 3**). Memories, for example, can be tested by checking their ability to read and write a complex set of patterns or by examining a model of their circuit design. As today's ICs achieve the complexity of yesterday's computers, the application-testing approach becomes easier, while circuit modeling becomes exponentially more complex.

Not only are LSI devices and μCs complex to model functionally, they also spawn a wide variety of common fault mechanisms (such as intermittent and dynamic failures) that defy deductive modeling altogether. For this reason, computer systems on boards or in mainframes




```
FF43                    ;♦♦♦ TEST   IEEE-488 INTERFACE
FF43                    ;
FF43  A6  00            BIEE    LDX  0
FF45  8E  22  E8        BIEE1   STX  IEEO
FF48  EC  20  E8                CPX  IEEI
FF4B  D0  FE            BF21    BNE  BF21     IEEE DATA LINE FAIL
FF4D  E8                        INX
FF4E  D0  F5                    BNE  BIEE1
FF50  2C  20  E8                BIT  IEEI
FF53  A9  FB                    LDA  #$FB
FF55  8D  40  E8                STA  PIA
FF58  2C  21  E8                BIT  IEEIS
FF5B  10  FE            BF22    BPL  BF22     ATN FAIL
FF5D  2C  40  E8                BIT  PIA
FF60  50  FE            BF23    BVC  BF23     NRFD STUCK LOW FAIL
FF62  4A                        LSR  A
FF63  8D  40  E8                STA  PIA
FF66  2C  40  E8                BIT  PIA
FF69  70  FE            BF24    BVS  BF24     NRFD STUCK HIGH FAIL
FF6B  10  FE            BF25    BPL  BF25     DAV STUCK LOW FAIL
FF6D  A9  34                    LDA  #$34
FF6F  8D  23  E8                STA  IEEOS
FF72  AD  40  E8                LDA  PIA
FF75  30  FE            BF26    BMI  BF26     DAV STUCK HIGH FAIL
FF77  4A                        LSR  A
FF78  90  FE            BF27    BCC  BF27     NDAC STUCK LOW FAIL
FF7A  A9  34                    LDA  #$34
FF7C  8D  21  E8                STA  IEEIS
FF7F  4E  40  E8                LSR  PIA
FF82  B0  FE            BF28    BCS  BF28     NDAC STUCK HIGH FAIL
FF84  A9  02                    LDA  #2
FF86  8D  43  E8                STA  P2DA
FF89  8D  41  E8                STA  SYNC
FF8C  2C  10  E8                BIT  PIAL
FF8F  50  FE            BF30    BVC  BF30     EOI STUCK LOW FAIL
FF91  8E  41  E8                STX  SYNC
FF94  2C  10  E8                BIT  PIAL
FF97  50  05                    BVC  BLED
FF99  EA                        NOP
FF9A  EA                        NOP
```

Fig 3—The diagnostic self-test program *of the Commodore PET serves as that computer's sole GO/NO-GO production test. A portion of the program appears here.*

Combining system and functional testing cuts costs and leadtime

receive final application-program testing as *computers,* not as collections of circuit models capable of a limited failure repertoire. In this sense, functional testing and system testing can be combined, with a variety of advantages.

Advances are occurring in the computer modeling of complex LSI devices, however. GenRad recently announced a Simulation Control Language (SCL) (**Refs 4, 5**) capable of modeling the 8080, 6800 and 2900 μPs and their support devices. This language can also model any new LSI device, including proprietary circuits. Finally, Fluke Trendar's advanced sequential diagnostic algorithm (**Ref 6**) can resolve failures on bus-connected μC boards while running real-time applications or self-test programs of arbitrary length.

System testing: easier, but with tradeoffs

Getting the most out of a μC's final system testing requires putting the test program into an inexpensive, on-board ROM. The result? Built-in functional and system self test that's useful not only for production testing, but also for field test, customer verification and even lab evaluation.

The self-test capability proves especially important in the field, for there μCs fall into the hands of nontechnical people. The standard field-service approach today involves swapping boards until the failure clears up, then sending the suspect ("bad") boards back to the factory for repair. The resulting board inventory can become expensive, so many test-equipment manufacturers now offer instruments dedicated to field service.

Many approaches to the design of such instruments have emerged. Miniature board testers marketed by Omnicomp, GenRad and Bendix operate much like the production testers already described. Other companies offer signature testing, using either transition counting or cyclic redundancy checks—Data Test pioneered the former, Hewlett-Packard the latter, and Millennium Systems has added the power of triggered signatures and emulation to extend the technique. Going a bit further, Paratronics has opened up the interesting possibility of achieving remote-control diagnosis through data communications, while Tektronix and Data Test offer transition-counting signature testers that also measure every common analog parameter including the line voltage. Finally, Intel offers a logic-state analyzer with emulation capability.

It's too early to tell which of these approaches will prove most useful, but one thing is certain:

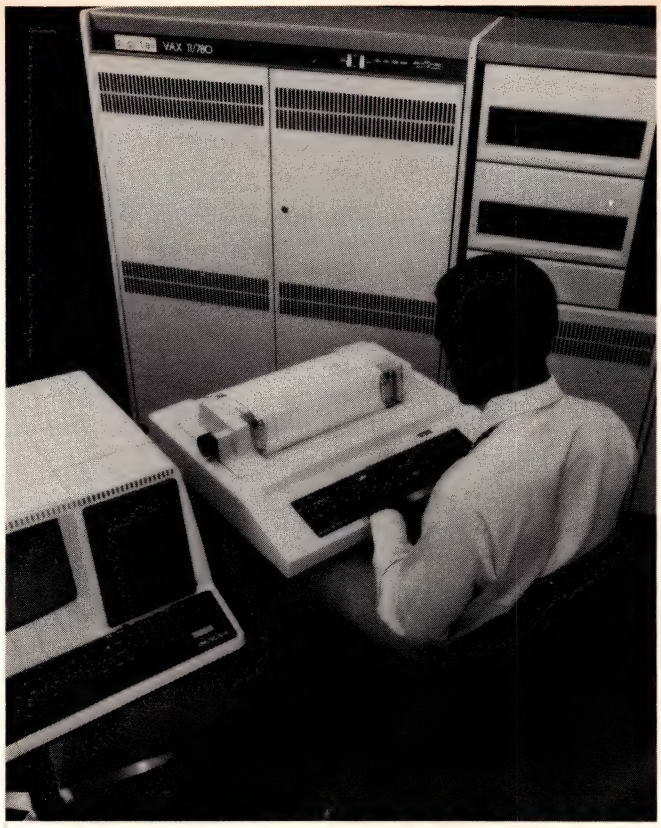


Fig 4—Large mainframe computers, *such as the DEC VAX-11/780, incorporate extensive diagnostic hardware to provide considerable diagnostic resolution.*

On-board self-test capability is essential. Watch out, though, for hidden problems with techniques that count on the existence of a working trouble-shooting tree for the response test. And remember that verification testing of a μC is easy, but relatively worthless. The trick is *diagnosis.* Also, beware of documentation implications. Ask yourself how expensive it will be to prepare the documentation for all your boards and to change that documentation in the field.

By changing to a system orientation and thoroughly exercising the functions of a μC instead of its internal circuits, testing that μC becomes easier than testing random logic. μCs have highly systematic architectures that are easy to plan for, and the system bus provides a universal monitoring point for verification and diagnosis; the approach might someday replace edge-connector testing. Potentially, on-board intelligence makes self testing and all its power available on every board in a system. A sequential diagnostic algorithm and the move away from combinatorial circuits automatically reduce the amount of probing required to diagnose a board. Use of the system bus and new diagnostic algorithms could even reduce the need for bed-of-nails fixtures.

For one good example of a self-test program, consider the Intellec microcomputer development system Diagnostic Confidence Test from Intel Corp (**Ref 9**). Loaded into a μC from a



Fig 5—Three field-service-oriented instruments—*the Hewlett-Packard Model 5004 signature analyzer* ***(a)****, Intel μScope 820* ***(b)*** *and Millennium μSA* ***(c)***—*are all designed for use with μC systems stimulated by self-test programs.*

diskette, this program sequentially checks the system CPU, RAM, TTY, CRT, diskette drives, line printer, paper-tape reader and paper-tape punch. It directly tests the CPU, RAM and diskette drive; the terminal, line printer and paper-tape reader/punch are tested through interaction with the operator, who provides inputs (eg, TTY keystrokes) and visually checks outputs (eg, a test message printed out on the line printer). The main use of the program is to verify that the user has hooked up the system properly and that all major subsystems are working.

Another system in which self test serves to instill user confidence and find faulty modules is the Fluke Model 8520A digital multimeter (**Ref 10**). When turned on, this instrument (**Fig 2a**) first determines which of its several optional modules are installed; thereafter, it periodically polls them for status information. Should a module known to be present fail to respond, or if it responds improperly, the instrument displays an error code. In addition, it identifies measurements that would require nonresident functional modules, as well as any invalid measurement limits and other operator errors, displaying an appropriate error code in each case.

The built-in test program of the Commodore Business Machines PET computer (**Fig 2b**) is so complete that it serves as the sole GO/NO-GO test for that system's production operation; ATE is only used to diagnose the NO-GO failures from self test. A 30-sec self test fully verifies proper operation of the CPU, 8k of RAM, I/O ports and video-display circuits, lighting an on-board LED upon successful completion. In addition to its production function, this self-test program (**Fig 3**) provides an excellent field-verification test for use by nontechnical customers and sales personnel. Written in 6502 assembly language, it only occupies 1k bytes of program memory.

Ascertain failure cause & location

These examples all point to self test as the most powerful technique for verifying proper operation of a μC-based system. But GO/NO-GO testing covers only half the problem—and by far the easier half. Once improper system functioning has been ascertained, the cause of the failure must be determined.

While all the self-test programs described so far have some diagnostic capability, their diagnostic resolution is very low. They can identify a faulty major subsystem, but they certainly can't diagnose faults down to the component level. Self-test, though, has also sometimes found use in large mainframe computers, where it provides much greater diagnostic resolution at the expense of considerable additional diagnostic hardware. For example, the DEC VAX-11/780 (**Fig 4**) has extensive diagnostic hardware additions.

It might thus appear that self test could only be a viable diagnostic tool for the largest μC

μCs require system-oriented, not circuit-oriented, testing

products, but don't be fooled by appearances. Designers are now realizing that it can serve smaller μC systems as well.

There are two reasons for this realization:

- Because of μCs' extreme complexity, they require very long test sequences to illuminate enough of their potential faults. There is simply no practical way to generate or manage this volume of stimulus data except by resorting to a self-test program that runs on the system under test.
- Many μC faults only occur in a complete system that runs at normal operating speed. Such soft (or dynamic) faults can result from the effects of noise, temperature or other parametric variations, and because they are intermittent and extremely dependent upon exact timing relationships, the only way to find them is to observe the system components communicating as the system functions normally.

The payoffs of incorporating self test into a μC are thus widespread. One of them accrues because the required test program is often already available as a result of the development process.

Design engineers commonly verify that their μC systems function as intended by preparing a set of test routines to exercise each module as it is designed and debugged. One such routine might be a loopback test program that serves to prove that a serial or parallel interface performs

A look at loopback test programs

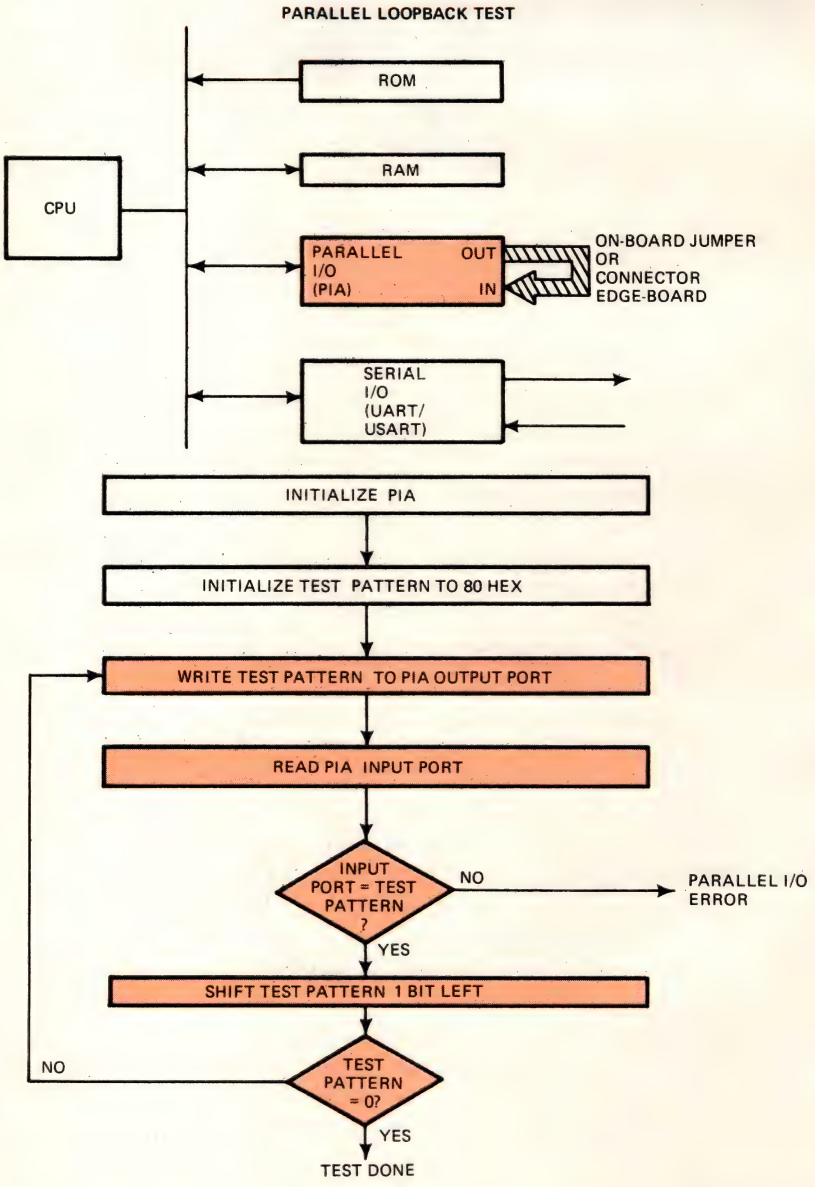
Written to verify the correct functioning of μC systems, loopback test programs divide into parallel and serial types.

In a *parallel-I/O loopback test,* output ports are connected to input ports so that data written to the parallel interface can be read back into the CPU and checked. You can make the loopback connection with on-board jumpers or with a special edge-board test connector.

The program tests all bits of both the output and input ports by ensuring that they respond to both LOW and HIGH signals. Although this test does not explicitly determine whether an error exists in input or output, LSI parallel-interface chips (such as the 6820 or 8155) do not require such verification so long as the faulty device is pinpointed.

If the I/O ports are implemented with control signals for handshaking, you can also loop-back these control signals. In that case, the test routine would have to follow the handshaking protocol. For example, writing data to the output might cause an interrupt, resulting in the input's being read and compared.

Basically, the *serial loop-*



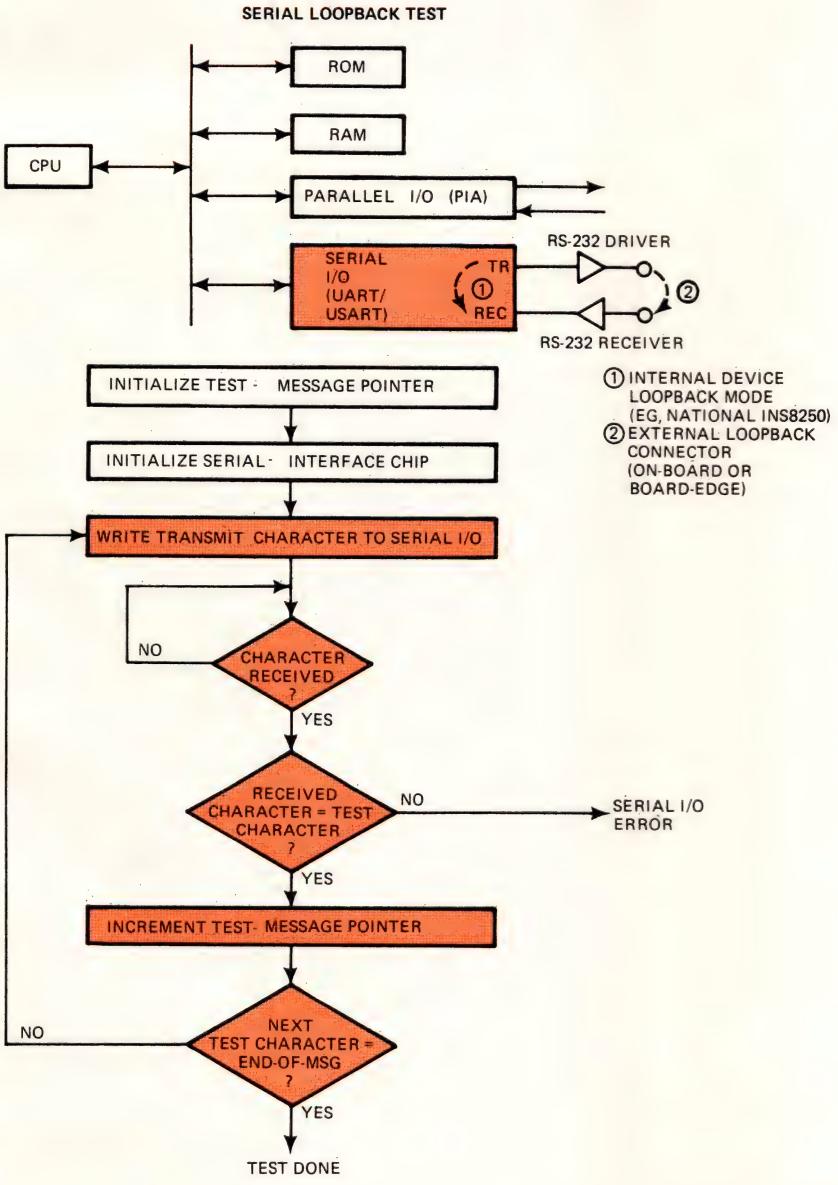
according to specifications. Gathering a collection of such verification modules provides ready-made material for the product's self-test program.

But even if you can't collect self-test software from the development effort, preparing it from scratch requires much less effort than writing a test program in the special language of an automatic tester. Familiarity holds the key here; self-test programs are written in the language of the system's μP, by the designer who understands the system most fully, and on a development system with which that designer is very familiar. Furthermore, there is a far closer relationship between the self-test code and the operation of the system than between the ONEs and ZEROs specified in a tester program and the way the system functions. As a result, it's much easier to see how a particular piece of test code stimulates the system; greater fault coverage becomes easier to achieve. Also, because the test code relates more closely to the system's structure, it's easier to modify the test program to allow for hardware revisions. In the future, IC vendors could supply portable, relocatable self-test code segments for each LSI device. Then, all a user will have to write will be special I/O tests.

Instruments complement self test

Of course, a self-test program can't single-handedly debug a μC system. New tools designed to work with that program must augment it.

In response to the strong demand for such equipment, several new instruments have recently been introduced; each serves μC systems stimulated by self-test programs. Among these



back test involves connecting the transmit output of a serial interface to the receive input. Many serial-interface ICs allow programming of a loopback mode in which the connection occurs internally—a configuration that allows testing of the serial-interface chip independently of its external circuitry. Once this test has been performed, the external circuitry, which usually consists of RS-232 drivers and receivers, can be similarly tested by means of an external connector or jumper.

The serial loopback program shown here polls a serial interface to determine when the transmitted character has been received. In an interrupt-driven interface, this polling process would be replaced by a state in which the processor waits for the received-data-available interrupt. In response to this interrupt, the received data would be read and compared with the transmitted data. Note that some modem-control signals might have to be either looped-back externally or strapped to active levels to allow loopback to occur.

instruments are Hewlett-Packard's Model 5004 signature analyzer (**Ref 12**), the Intel μScope 820 and the Millennium μSA (**Ref 13**) (**Fig 5**). For further information on the operation of this class of instruments, see EDN, October 5, 1978, pgs 89-99.

Unlike these instruments, which are designed primarily for field service, Fluke Trendar's Model 3040A Logictester (**Fig 6**) addresses production needs. It employs a sequential diagnostic algorithm (SDA) to locate system faults through the use of self-test stimuli. Basically a hardware comparison tester, it relates the unit under test to a known good reference; both systems run at real-time speed. Thus the tester can find the first failure to occur as the system under test runs its self-test program. The SDA identifies—through μP address, data and status—which device was active on the system bus when the first failure occurred. The tester clips onto the system μP, which therefore need not be socketed.

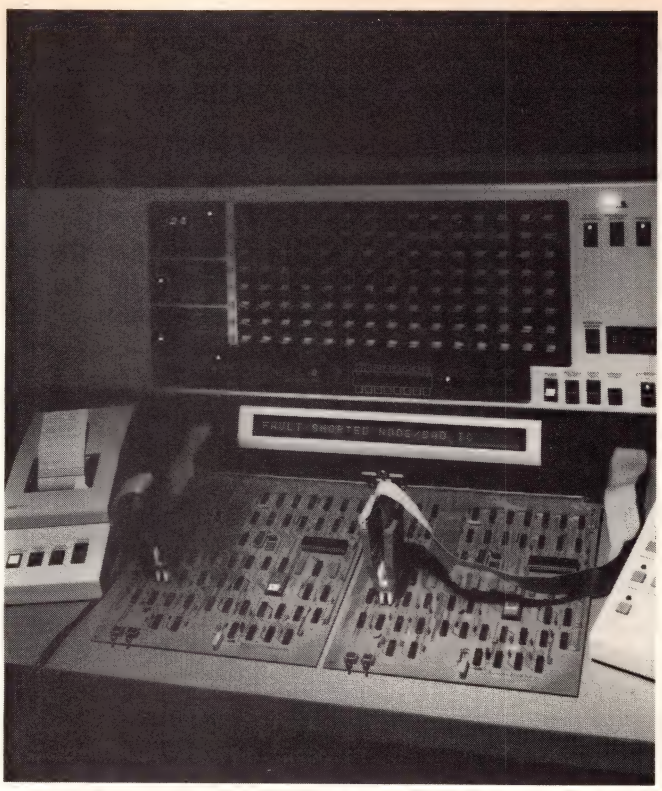
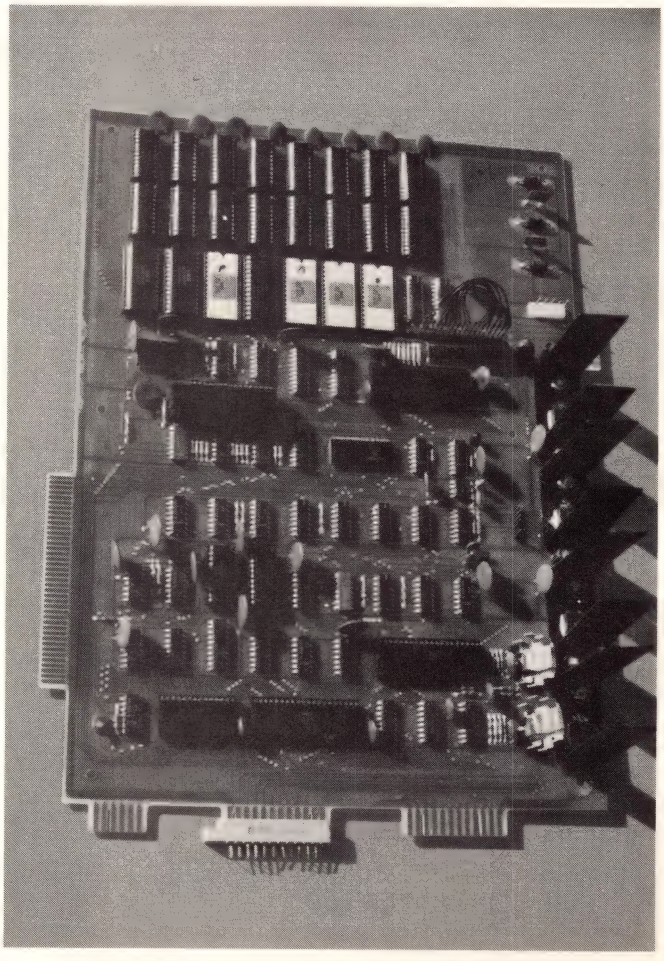


Fig 6—Clipping onto the system μP, *Fluke Trendar's Model 3040A Logictester employs a sequential diagnostic algorithm to locate system faults illuminated by self-test stimuli.*

Fig 7—Proper I/O-port design *allows the routing of outputs on the Commodore PET's board back to inputs by means of a diagnostic test connector (note the added LED indicator).*



Design engineers take the stage

The new instruments being developed around a self-test strategy should be a clear signal of the importance of this strategy. And as self test grows even more important, the job of providing test software will undoubtedly shift from the test engineer to the design engineer, who will have to understand the nature of the testing process in order to provide the most effective self-test programs. By following a few simple principles and guidelines, these designers can quickly and easily generate flexible, comprehensive and efficient self-test software:

- Usually, you can include self-test code along with the application program. It doesn't take up much space, and making it resident on the μC board increases its usefulness in production and in the field. Also, executing the self-test program every time the system is turned on is a good way to build customer confidence. If resident self test is not feasible, though, you can build-in a socket for a test-program ROM; then production workers and field-service personnel can easily add the test program to the system. And if you can't justify even an empty socket and the address decoding to go with it, provide a means by which a tester can disable the system-address decoder. Then a self-test program can be overlayed onto the tested system's memory space.
- Provide a way to selectively run the self test. Running it automatically at power-on

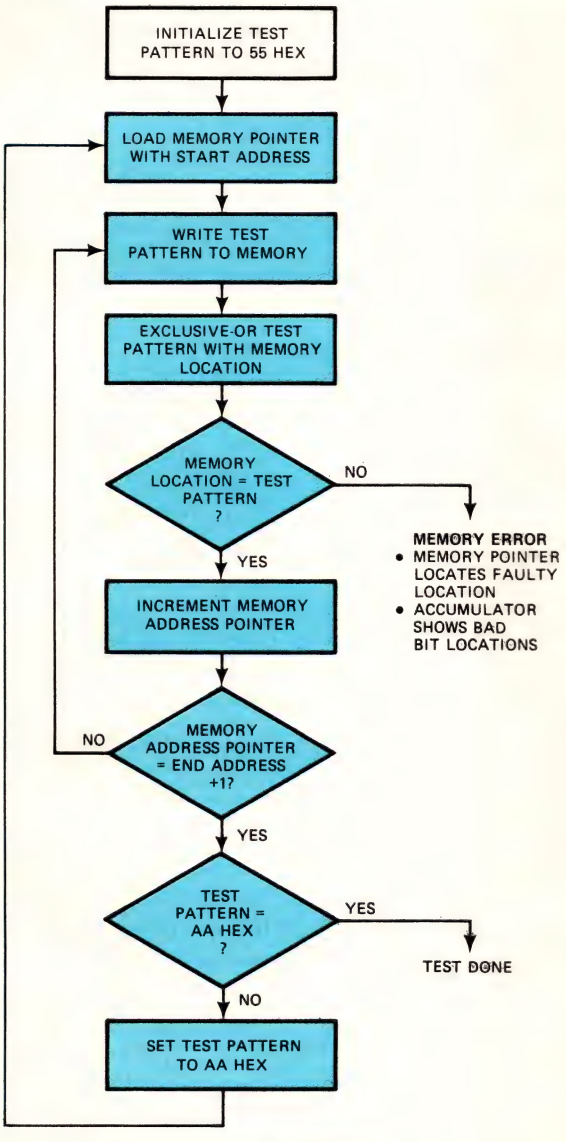
System-independent test modules

Many software functions depend not on the specific application, but rather on the processor on which that application runs. They thus lend themselves to use in self-test programs.

The RAM-test module shown here is a good example of such a system-independent test module. Once parameters defining the starting and ending locations have been specified, it can serve any 8080-based system.

This memory-test routine propagates a checkerboard pattern through memory. After this test pattern is written into the memory, the current memory location is compared with the test pattern via an exclusive OR—a procedure that results in the appearance in the accumulator of a bit map of the failing-bit locations. When a fault is found, the memory pointer in the HL register pair points to the faulty location. Both 55_{16} and AA_{16} serve as test patterns to ensure that each location is tested for both a ONE and a ZERO.

System-independent test modules provide an excellent opportunity to reduce test-programming costs. The only cost for using this approach is setting up and following a convention for passing system-related parameters to the test module. In this example, that process is implemented by reassembling the test module with addresses RAM: and RAMEND:, suitably positioned for the particular system. Other techniques, such as passing parameters from the main self-test program to a system-independent subroutine, are also possible.



DEDICATED STORAGE LOCATIONS
MEMORY START ADDRESS–2 BYTES
MEMORY END ADDRESS + 1–2 BYTES

```
        MVI   B, 55H      ;INIT TST PATT.
PTRIN:  LXI   H,STADR     ;INIT MEM PTR
MEMWRT: MOV   M,B         ;WRITE MEM
        MOV   A, B        ;PATTERN → A .
        XRA   M           ;CMP WITH MEM
        JNZ   MEMERR      ;JUMP IF ≠
        INX   H           ;INCR MEM PTR
        LDA   ENDH        ;LOAD END ADDR HI
        CMP   H           ;CMP WITH PTR HI
        JNZ   MEMWRT      ;LOOP IF ≠
        LDA   ENDL        ;LOAD END ADDR LO
        CMP   H           ;CMP WITH PTR LO
        JNZ   MEMWRT      ;LOOP IF ≠
        MOV   A, B        ;LOAD PATTERN
        CPI   ϕAAH        ;IS IT AA HEX?
        JZ    TSTDON      ;IF SO, TEST DONE
        MVI   B, ϕAAH     ;PATTERN = AA HEX
        JMP   PTRIN       ;DO IT AGAIN
MEMERR:                   ;PROCESS
                          ;MEMORY
                          ;ERROR

TSTDON:                   ;CONTINUE


STADR:  DW    RAM         ;START ADDR
ENDL:   DW    RAMEND      ;END ADDR+1
        ORG   *-1
ENDH:
        ORG   RAMLOC      | THESE ARE
              N           | THE SYSTEM-
                          | DEPENDENT
                          | PARAMETERS
RAM:    DS                ;START OF RAM
                          ;N BYTES LONG
RAMEND:                   ;END OF RAM+1
```

Self-test software often comes from the development effort

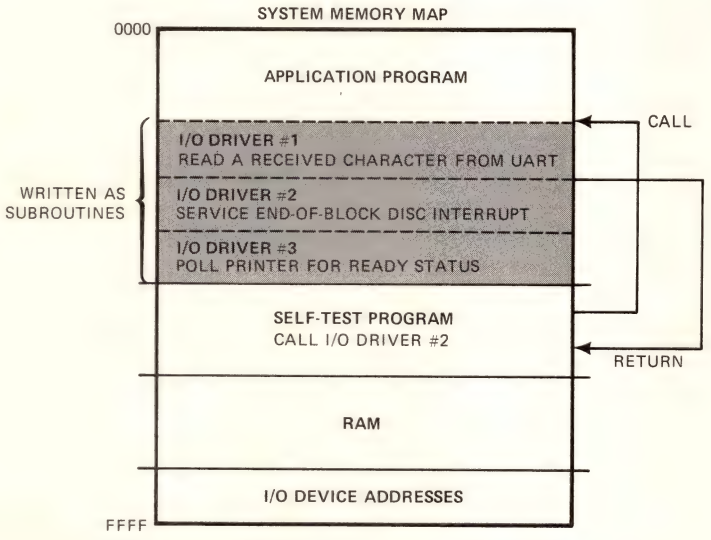
is a good idea to check out some of the system components such as CPU, ROM and RAM. Adding a self-test switch or a special jumper lets service personnel access the self test when needed.

- Design I/O ports so that outputs can be routed back to inputs with a test connector (see **Fig 7** for the way the Commodore PET board accomplishes this task). This approach allows a very effective test of the I/O circuitry.
- Use built-in timer functions to check critical I/O timing signals. Routing these signals to timer inputs through the test connector lets you accurately measure timing parameters.
- μC systems are inherently partitioned by the way I/O or addressed memory is assigned to system components. Modularize the self-test program according to this functional partitioning. Then structure the self test to examine one function at a time (eg, CPU test, RAM test, I/O port #1 test, I/O port #2 test, etc). This procedure lets you isolate faulty subsystems and components without allowing faulty responses to propagate through the entire system.
- Arrange self-test modules so they can run continuously (to provide continuous stimuli for tracking down faults) or in sequence (for a full-verification test).
- Some test modules can be general-purpose ones, useful in many systems. Such modules include those for CPU test, RAM test and ROM test; they can serve all applications using a particular μP.
- Write application-program modules as subroutines; you'll then be able to call them from the self-test program and save code space. I/O-driver routines provide a good example of the type of subroutine that can reside in the application program and be used by the self-test program.
- Remember that all testing involves comparing the tested system with a reference that describes the way the system should work. This fact means that the tested system must start in a predetermined state. Design engineers have long been told to make sure that all of their hardware can be initialized—a fact that's important in μC systems as well. Equally important, care must also be taken that all software memory elements are initialized for testing pur-

Existing I/O routines aid in self test

Self-test programs can be shortened significantly if they have access to I/O routines that already exist in an application program. Examples of such I/O driver routines are:

- Service a serial interface (read a received character, write a character to be transmitted, determine line status)
- Scan a keyboard
- Initiate a disc transfer or service an end-of-transfer interrupt
- Initialize a PIA.



Many other possibilities exist. The key point is that by writing these commonly used routines as subroutines, you can call them from the test program and therefore don't need to repeat them there. A side benefit of this procedure is that these subroutines are then easy to use in other system applications when common I/O devices or functions exist.

Note that when application-program subroutines are used by a self-test program, their use should be preceded by a test of the program-memory elements in which they reside.

poses. As a general rule, any storage location the processor can read must be written to before it is read. While this rule sounds simple enough, be careful of storage elements that are read into the CPU implicitly as a result of processor operation or architecture. For example, consider uninitialized processor-status bits (eg, carry, zero parity) that are pushed onto the stack on an interrupt and then read back into the CPU on return. While the programmer might not be explicitly aware of it, these uninitialized bits are read into the processor in exactly the same manner as any memory location.

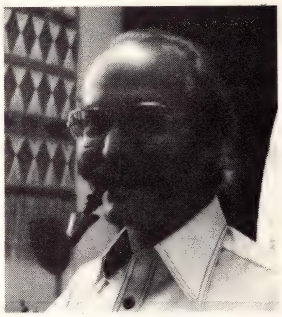
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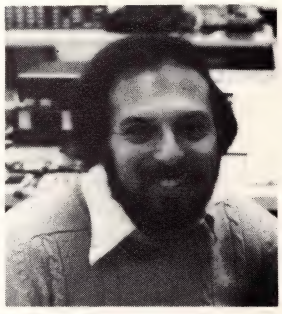
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Authors' biographies



Edward S Donn, formerly a project manager at Fluke Trendar's Automated Systems Division, Mt View, CA, now manages the innovation department at ESI, Portland, OR. He received his BSEE from the University of Florida, attended the University of Arizona, Denver Univ and Colorado State University, and holds two patents. Ed lists mountain climbing, white-water rafting and canoeing among his hobbies.



Michael D Lippman was a project engineer engaged in developing automated test equipment for microcomputers at Fluke Trendar when this article was written. He currently works for EG&G/Reticon, Sunnyvale, CA. Mike holds both a BEE and an MSEE from New York University and has two patents to his credit. He chaired the System and Board Test Subcommittee of the IEEE Computer Society Test Technology Committee, is a member of Tau Beta Pi and Eta Kappa Nu, and counts tennis, camping and hiking as hobbies.

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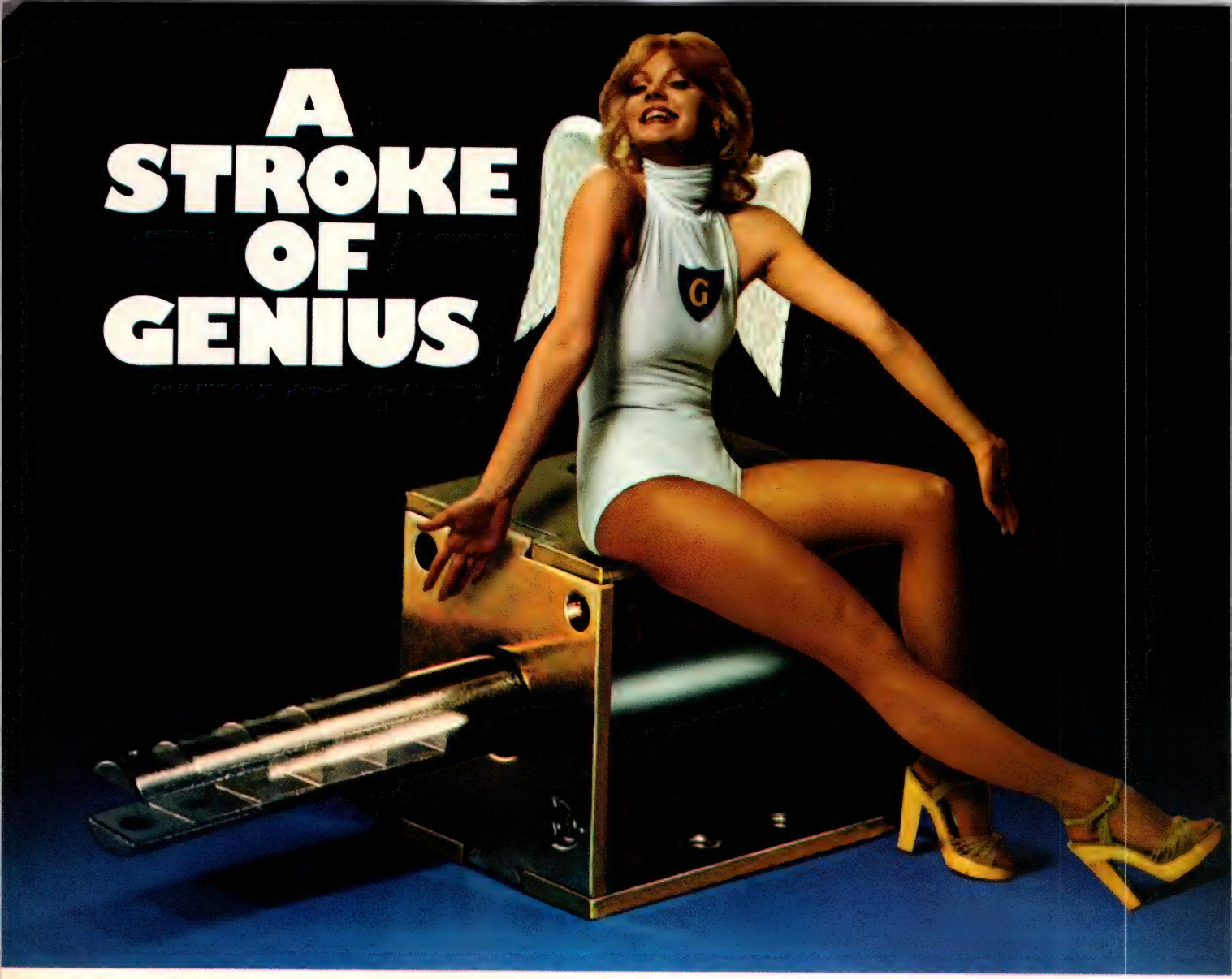
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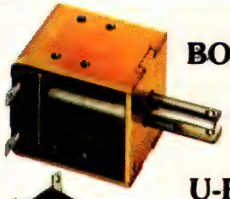
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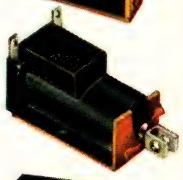
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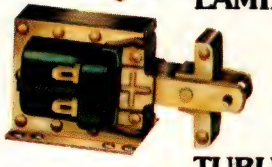
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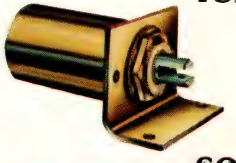
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Analyze active-network responses without complex manipulations

By using a "divide-and-conquer" process to modularize the computation of transfer functions, you can reduce calculations to the handling of simple first-order poles and resistive voltage-transfer ratios.

A M Davis, San Jose State University

Considering active networks' well-known advantages of low cost, small size and easy mass fabrication, it's safe to say that they are here to stay. Unfortunately, the use of op amps in such circuits tends to make their analysis by traditional methods tedious and time consuming.

However, there are ways to circumvent this difficulty. The method of analysis (**Ref 1**) discussed in this article permits rapid calculation of the voltage-transfer function of active networks. It is an extremely intuitive, time-saving and simplified procedure consisting only of the analysis of a sequence of single-capacitor circuits. In fact, to make the required calculations, you need only deal with driving-point resistances and resistive networks' voltage-transfer ratios, thus circumventing more complex calculations. And as a bonus, this analysis technique provides a way of quickly determining the filter type of a given network (high-pass, low-pass, etc)—a determination that can often be accomplished by inspection of the circuit involved.

Start with some basics

As a preliminary stage in the analysis of multiple-capacitor networks, consider a network with a single capacitor (**Fig 1a**). The voltage-transfer function of such a network is

$$H(s) = \frac{H_\infty s + H_0 P}{s + P} \qquad (1)$$

where H_∞ is the high-frequency gain, H_0 is the dc gain and P is the pole. The form of the equation can be justified by the following derivation.

A single-capacitor network generates a single pole—**Eq 1**'s denominator is correct. By analyzing a resistive dead network (**Fig 1b**), you can

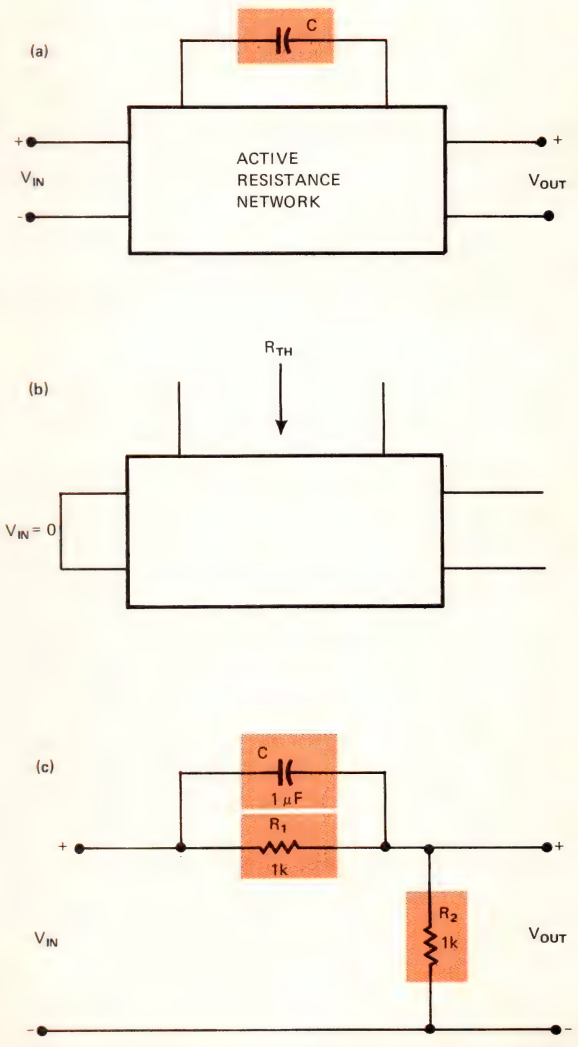


Fig 1—No complex manipulation is required *to derive the final form of a single-capacitor-network transfer function* ***(Eq 1)****. The parameters required for such a derivation can usually be determined by inspection.*

No complex calculations needed to derive the transfer function

then calculate the pole P (actually the negative of that pole) from

$$P = \frac{1}{R_{TH}C}.$$

If s is allowed to approach infinity (by shorting C), the high-frequency gain (H_∞) must result. As is clear from **Eq 1**, this does occur. Similarly, letting s approach zero results in the dc gain H_0.

The single-capacitor network of **Fig 1c** provides a good example of **Eq 1**'s practicality. By inspection, you can derive the three parameters required to determine H(s): $H_\infty=1$, $H_0=1/2$ and P=2000 rad/sec. Therefore,

$$H(s) = \frac{s + 1000}{s + 2000}. \quad (2)$$

Notice that no complex manipulation is required to immediately place the network transfer function in this final form.

Added capacitor presents no problem

Now consider a circuit with two capacitors (**Fig 2a**). Here

$$H(s) = \frac{a_{12}C_1C_2s^2 + (a_1C_1 + a_2C_2)s + a_0}{b_{12}C_1C_2s^2 + (b_1C_1 + b_2C_2)s + b_0} \quad (3)$$

where the a and b coefficients are constants to be determined. The maximum order of the numerator and denominator is clearly two, and the only way to generate any such power of s is in conjunction with a capacitance in a C×s product. Thus, the expression includes all possible products of two capacitive admittances. The problem, therefore, reduces to evaluating the transfer function's a and b coefficients (**Ref 2**).

You can express the numerator coefficients in terms of those in the denominator by letting the capacitances C_1 and C_2 approach infinity or zero in value (the associated capacitors thus become shorts or open circuits, respectively). If you allow C_1 and C_2 to become infinite simultaneously,

$$a_{12} = H_{12}b_{12} \quad (4)$$

where H_{12} is the transfer function evaluated with C_1 and C_2 shorted. Similarly, letting C_1 become infinite and C_2 approach zero yields

$$a_1 = H_1b_1 \quad (5)$$

where H_1 is the transfer function with C_1 shorted and C_2 open. Pursuing this technique further yields

$$a_2 = H_2b_2 \quad (6)$$

and

$$a_0 = H_0b_0 \quad (7)$$

where H_2 is the transfer function with C_1 open and C_2 shorted, and H_0 is the transfer function with both capacitors open.

You can evaluate the b coefficients by performing essentially the same short-circuiting and open-circuiting manipulations. Permitting C_1 to approach infinity while holding C_2 constant results in the characteristic polynomial

$$b_{12}C_2s + b_1. \quad (8)$$

To substantiate this derivation, look at the denominator of **Eq 3**. It's clear that b_1 can be related to b_{12} by

$$b_1 = P_2^1b_{12}C_2 \quad (9)$$

where P_2^1 is the pole due to C_2 with C_1 shorted. Repeat this procedure for various capacitor

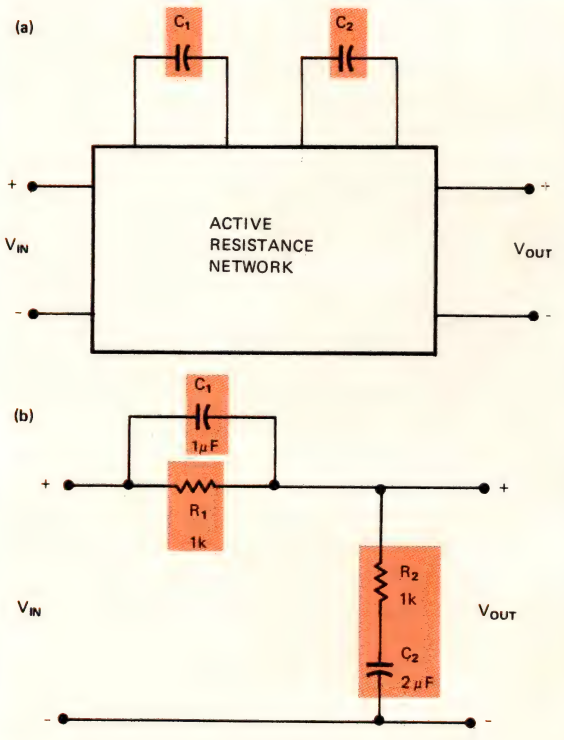


Fig 2—Dual-capacitor networks *submit easily if you work with only one capacitor at a time while alternately shorting or opening the second device. This scheme dramatically simplifies the calculations of the transfer function's* ***(Eq 10)*** *coefficients.*

Miller effect clarifies active-filter analysis

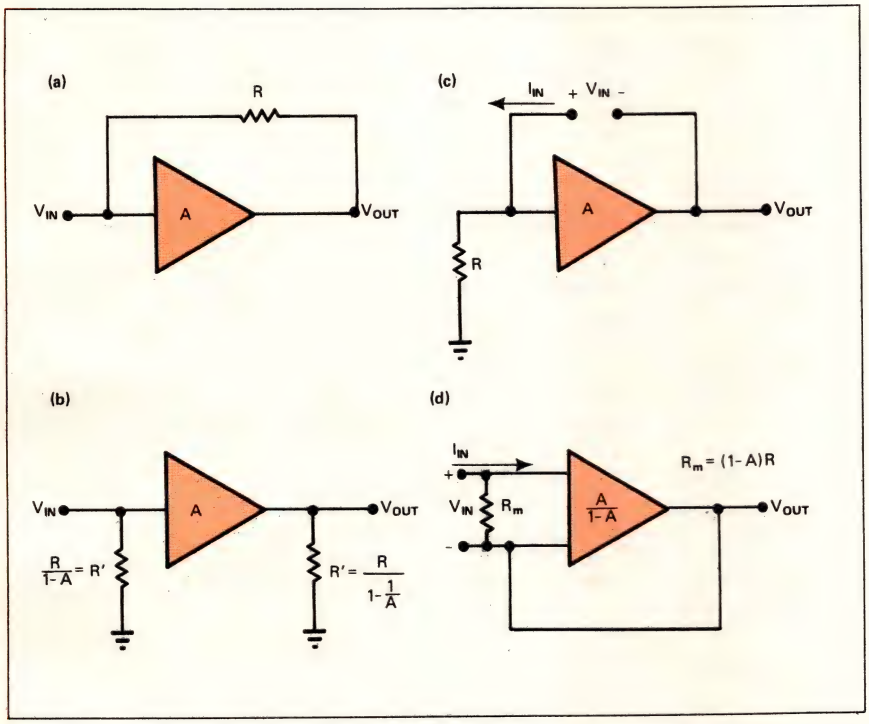
The Miller effect can come into play in either of two basic situations. In one **(Fig a)**, an ideal amplifier with gain A has a resistor connected from the output back to the input. As shown in many standard textbooks **(Ref 4)**, **Fig b** is an equivalent circuit. This equivalence can also be seen by noting that

$$I_R = \frac{V_{IN} - V_{OUT}}{R} = \frac{\frac{V_{IN}}{R}}{1 - \frac{V_{OUT}}{V_{IN}}} = \frac{\frac{V_{IN}}{R}}{1 - A}$$

and that

$$I_R' = \frac{V_{OUT} - V_{IN}}{R} = \frac{\frac{V_{OUT}}{R}}{1 - \frac{V_{IN}}{V_{OUT}}} = \frac{\frac{V_{OUT}}{R}}{1 - \frac{1}{A}}.$$

In a similar manner, if you write an expression for I_{IN} of **Fig c** (the second case), you can easily see that **Fig d** represents an equivalent circuit in that case.



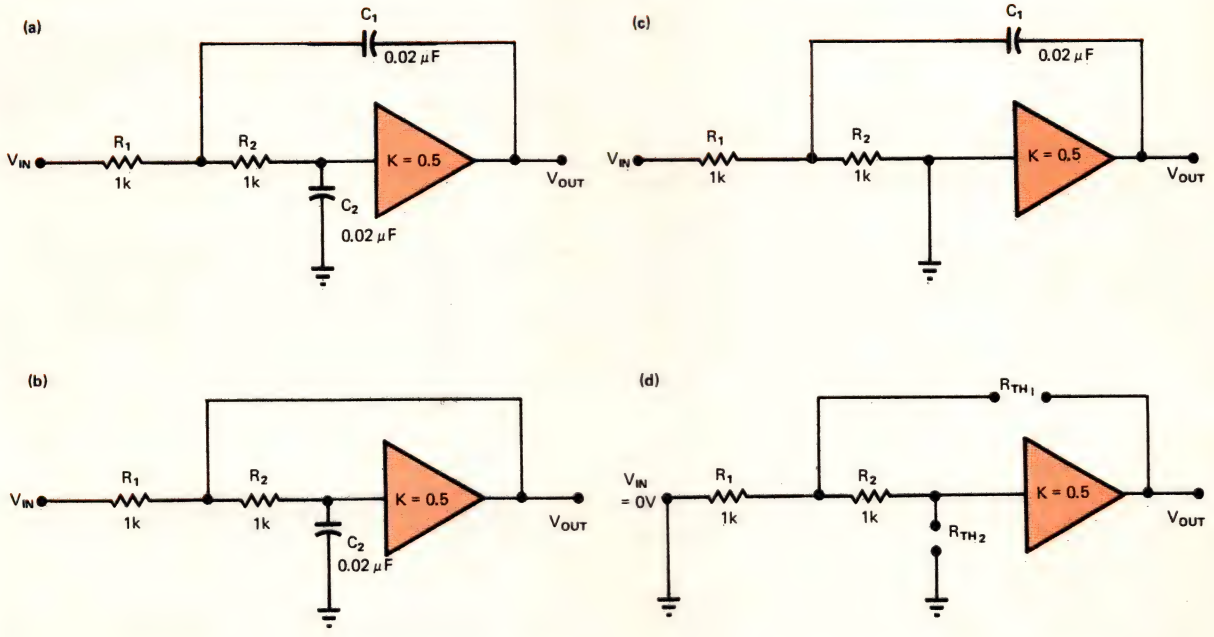


Fig 3—The simplicity *of the "divide-and-conquer" technique is borne out in the analysis of the classical active-filter circuit* ***(a)***.

Resistive voltage-transfer ratios can be determined by inspection

combinations to obtain

$$H_s = \frac{H_{12}s^2 + (H_1P_2^1 + H_2P_1^2)s + H_0\left\{\begin{matrix}P_1^2P_2\\ \text{or}\\ P_2^1P_1\end{matrix}\right\}}{s^2 + (P_2^1 + P_1^2)s + \left\{\begin{matrix}P_1^2P_2\\ \text{or}\\ P_2^1P_1\end{matrix}\right\}}. \quad (10)$$

Note that P_2^1 is the pole due to C_2 with C_1 shorted and that P_1^2 is defined similarly. If a P has no superscript, the capacitor not referred to in its subscript is opened—as is the case, for example, with P_2, where C_1 is opened.

You can also determine the network filter type using these equations. Thus, for a given network, you can determine from **Eq 10** that if $H_0=H_1=H_2=0$, the network is a high-pass type; if $H_{12}=H_1=H_2=0$, it's a low-pass type; if $H_1=H_2=0$ but H_{12} and H_0 are nonzero, it's a band-reject network, while if $H_{12}=H_0=0$, the network is a bandpass type. These resistive voltage-transfer ratios can usually be determined by inspection of the network involved.

A passive-network example (**Fig 2b**) clarifies the process. By inspection, $H_{12}=H_1=H_0=1$ and $H_2=1/2$. Also $P_1^2=2000$, $P_2^1=500$, $P_1=1000$ and $P_2=250$. Thus,

$$H(s) = \frac{s^2 + 1500s + 500{,}000}{s^2 + 2500s + 500{,}000}. \quad (11)$$

Active-network analysis simplified

Sallen and Key (**Ref 3**) were the first to present the classical active-filter topology of **Fig 3a**. Shorting both C_1 and C_2 results in $H_{12}=0$; shorting C_1 (**Fig 3b**) gives $H_1=0$ by opening C_2. Note that because the amplifier's input and output voltage are the same, they both must equal zero. Shorting the input and looking away from C_2, you get $R_{TH}=R_2/(1\text{-}K)=2\ k\Omega$, so $P_2^1=(1\text{-}K)/R_2C_2=25{,}000$ rad/sec.

If you now short C_2 (**Fig 3c**), it becomes clear that $H_2=0$ if you also open C_1, and $P^2{}_1=(R_1+R_2)/R_1R_2C_1=100{,}000$ rad/sec. Finally, opening C_1 and C_2 gives $H_0=K=1/2$. The equivalent of **Fig 3d** can serve for the calculation of P_1 and P_2.

Taking the Miller effect (see **box**) into consideration, $R_{TH1}=(1\text{-}K)R_1=500\Omega$ (note that R_2 is "floating"). In addition, $P_1=1/(1\text{-}K)R_1C_1=100{,}000$ rad/sec, and $P_2=1/(R_1+R_2)C_2=25{,}000$ rad/sec. Because $H_{12}=H_1=H_2=0$, this circuit (**Fig 3a**) is a low-pass filter with transfer function

$$H(s) = \frac{K\dfrac{1}{R_1R_2C_1C_2}}{s^2 + \left(\dfrac{1-K}{R_2C_2} + \dfrac{R_1+R_2}{R_1R_2C_1}\right)s + \dfrac{1}{R_1R_2C_1C_2}}, \quad (12)$$

or, for the values given,

$$H(s) = \frac{1.25 \times 10^9}{s^2 + 125{,}000s + 2.5 \times 10^9}. \quad (13)$$

The dc gain is, therefore, 0.5. Other circuit parameters are: $\omega_0=55{,}000$ rad/sec (7.96 kHz) and $Q=0.4$. **EDN**

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Author's biography

A M Davis is an assistant professor at San Jose State University, CA, where he teaches electronics and circuit theory. He also teaches at the University of Santa Clara, CA, and has worked at Bell Labs and Eastman Kodak Research Lab, in addition to doing consulting work at several other firms. Mr Davis' leisure-time activities include backpacking, ham radio, reading, free-lance writing and music.

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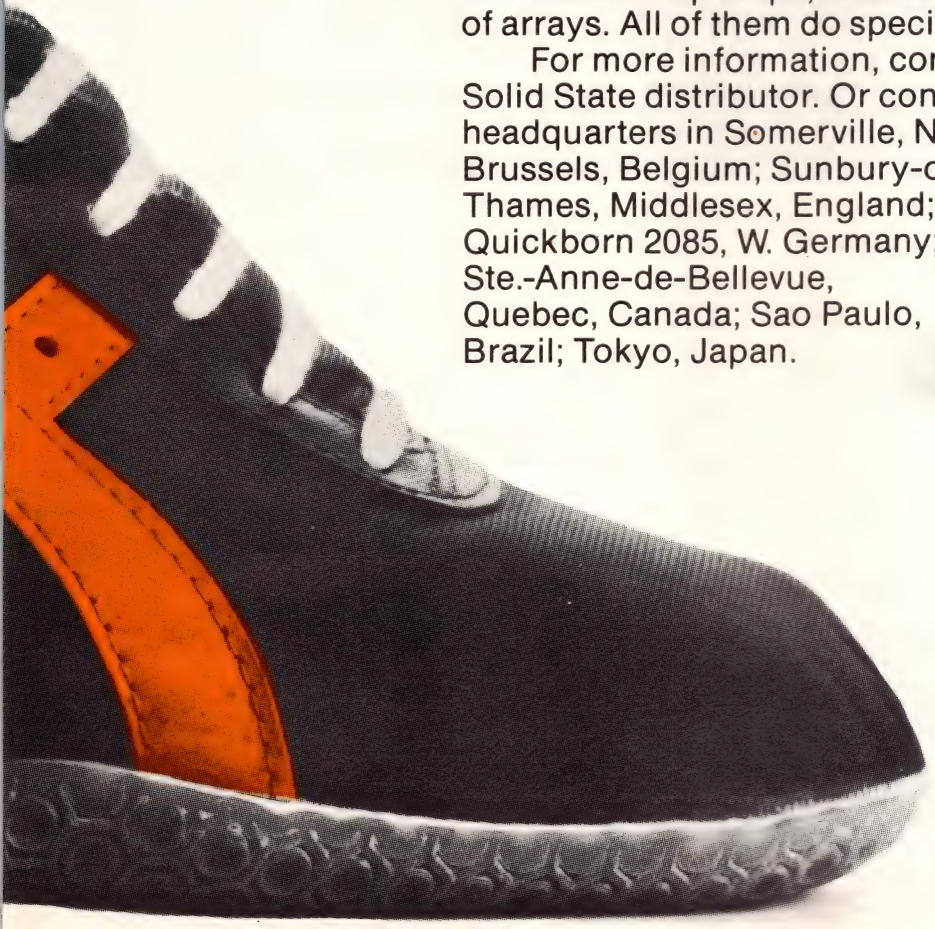
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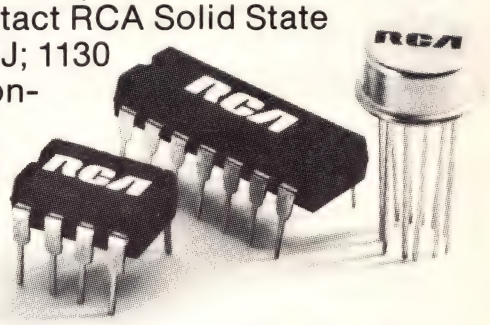
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Some simple hardware techniques allow fail-safe LSI interfacing

LSI-device designers don't always construct their chips the way you design your circuits; understanding this fact can prevent serious system operating problems and/or failures.

Carol A Ogdin, Consulting Editor

Although LSI devices provide many advantages, using them effectively requires recognizing that you're adopting someone else's designs—a procedure that could cause problems if your design practices and the ones embodied in these devices don't coincide. (See, for example, the editorial and guest editorial in EDN, December 15, 1978, pgs 19-22.) In extreme cases, you might have to forego using an LSI device entirely and rely instead on your own discrete-circuit designs. And in any case, you must understand the potential pitfalls LSI use can generate in interfaces.

When power fails, take care

One factor frequently overlooked in LSI-chip design is the need to interface two or more LSI devices powered from separate supplies. When a technician shuts off power to one side of such an interface, or when the power fails, your system must allow for the possibly catastrophic effects of this power-down. In extreme cases, the remote IC can self-destruct.

But even if you don't worry about LSI-device failure in such a system, you must be concerned with the electromechanical equipment the system controls. It's imperative in many process- and industrial-control applications, for example, that in the absence of logic power, the peripheral devices should revert to a benign state. Available LSI chips might not by themselves support this action, and using them might force you to adopt special hardware techniques. (Note that you can't solve this problem with software, because the computer might lose power—preventing execution of any instructions.)

Consider, for example, a microcomputer that issues an active-LOW ON to a motor-control circuit. If properly designed, the circuit would force the solid-state relay controlling the motor to turn the motor off when unenergized. In **Fig 1,** though, the circuit violates this fail-safe condition—if the computer loses power, ON is pulled to near ground, and the motor is left running. And if the motor controls a crane, the boom might swing around and hit somebody.

Fail-safe operation thus requires that the resting or stop condition of a signal controlling a device should approach ground; ie, a disconnected signal line should cause this control signal to remain LOW. But at the same time, the actions that occur at the connection's far end should be invoked only with positive logic signals, and they should be producible only under the strictest of conditions. These two considerations are summarized as follows:

Rule 1—Always use positive logic for control.
Rule 2—Resting condition should be at ground.

You can apply these rules easily when your interface circuitry is composed of SSI or MSI gates; however, an LSI device in the chain might necessitate doing some detective work to ensure fail-safe operation. The partial diagram in **Fig 2,** taken from a recent application, illustrates a

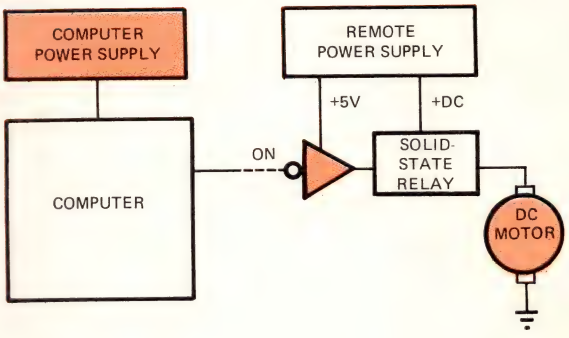


Fig 1—This circuit violates fail-safe design rules *and can cause a peripheral device controlled by the dc motor to move erratically if power fails.*

LSI devices can complicate fail-safe design problems

case in point. The computer in this system is an Intel iSBC 80/20 connected over a cable to a nearby digital-cassette-recorder controller. That controller, based on the 8741 universal programmable interface, gets its power from a source other than the computer's. The problem? Each time the computer's power was turned off for the night, the 8741 would refuse to operate the next morning; it had died, and had to be replaced before system operation could resume.

One possible solution to this problem was simple: Instruct the operator to always turn the power to the 8741 off *before* cutting the computer's power. But that's an unsatisfying (and risky) solution; a better one is possible.

Beware of the unpowered lead

Why was the 8741 destroying itself? Look carefully at **Fig 2**; the 8741 communicates with the computer through an 8-bit bidirectional data bus. Now consider three important 8741 control signals: $\overline{CS}$, $\overline{RD}$ and $\overline{WR}$ (chip select, read and write, respectively). Holding CS and RD LOW enables the 8741's drivers and produces data on the eight data lines; holding CS and WR LOW enables the receivers and allows the chip to accept data. The 8741 data sheet clearly states that RD and WR should not be simultaneously held LOW.

When the computer's power is removed while power remains on the 8741, what signal levels prevail at CS, RD and WR? Ground, of course. Therefore, the 8741 is selected for both reading and writing—a clear violation of its design rules. Nevertheless, although the action might be confusing to the internal logic, and some strange

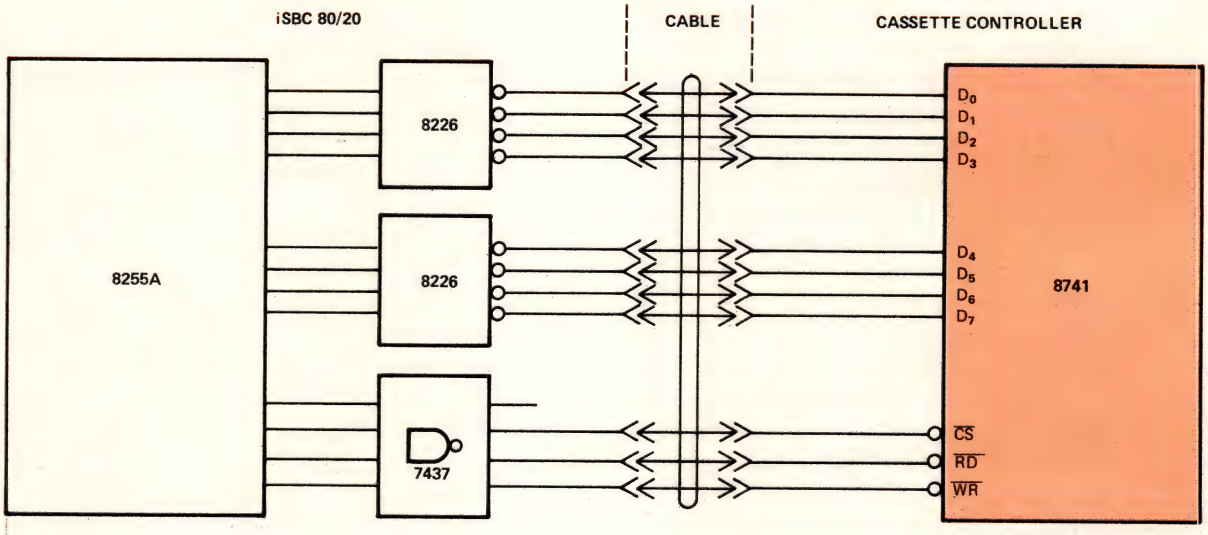


Fig 2—The cassette-controller chip (8741) *in this circuit self-destructed whenever the iSBC 80/20 computer was turned off while the interface was powered up.*

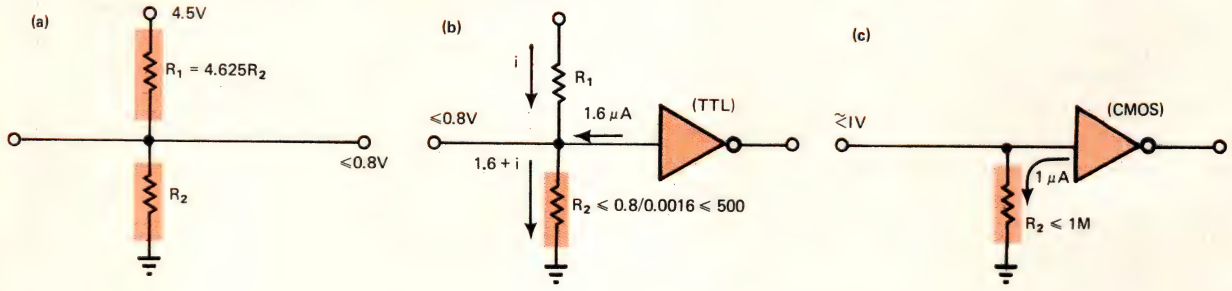


Fig 3—The pull-down resistor divider (a) *holds an otherwise undriven level at logic ZERO. For TTL gates, the pull-down is unreasonably small* ***(b)****, but CMOS allows a value large enough to prevent loading down of the preceding stages* ***(c)****.*

results might be obtained, the part shouldn't self-destruct—as it did. The cause must lie elsewhere.

Analysis reveals that the 8741 was destroying its output buffers. Why? Observe that when turned off, the computer holds both CS and RD LOW—an action that produces no ill effects if computer power is present. But with no computer power, the 8741's output drivers see a load composed of an unpowered 8226 Schottky-TTL-inverter input stage. Unfortunately, for all intents and purposes, this load looks like a diode connected to ground—a virtual dead short. It doesn't take long for the large current flowing through that diode to exceed the drive capacity of the one or more 8741 data lines that happen to be at the logic-HIGH level. Within a couple of milliseconds, the heat buildup around the 8741's output drivers causes catastrophic chip failure.

The 8741 is clearly designed for direct connection to a host computer—the data bus and control signals are all designed for compatibility with contemporary μPs. The part's designers concerned themselves with increasing the ease of interfacing to a μP housed on the same circuit board and did not intend the chip to serve remote applications. But the solution to the problem is not difficult: Invert the control signals from the computer and mount the necessary inverters on the same circuit-card assembly as the 8741.

With this modification, the control lines to the 8741 circuit conform to Rule 1 (positive logic). But a TTL inverter, when its input is left unconnected and floating, rapidly drifts into a state in which its output is held LOW—an action that doesn't conform to Rule 2 (near ground). You should therefore design your circuit to ensure that even if the signal to the inverter's input is disconnected, the input remains LOW—a status you can achieve with a pull-down resistor.

CMOS to the rescue

A pull-down resistor connected to a TTL input should be as large as possible to minimize current drain when the line's logic level is HIGH, but should be as small as possible to provide firm pull-down. To ensure that the input to the inverter stays below 0.8V, you can insert a voltage divider (**Fig 3a**). Assuming a worst-case V_{CC} of 4.5V, R_1 must be at least 4.625 times as large as R_2. Adding the inverter's input-current demand (**Fig 3b**) establishes the maximum values for the resistors.

Note that to sink the 1.6 mA demanded of a TTL input stage, R_2 can't be larger than 500Ω. Of course, an IC driver connected to such a circuit must supply the trivial input current demanded of the TTL inverter, plus the current drawn by the 500Ω resistor to ground. To pull that inverter above 2V, the driver must source at least 4 mA (for greater margins, it must source a current closer to 8 mA). Certainly TTL drivers can

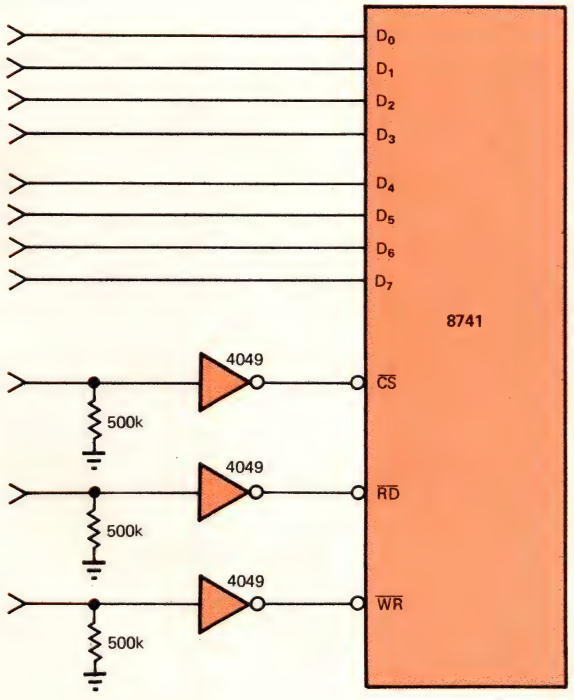


Fig 4—Using only positive logic for control signals *protects the 8741 from being placed in an unacceptable state.*

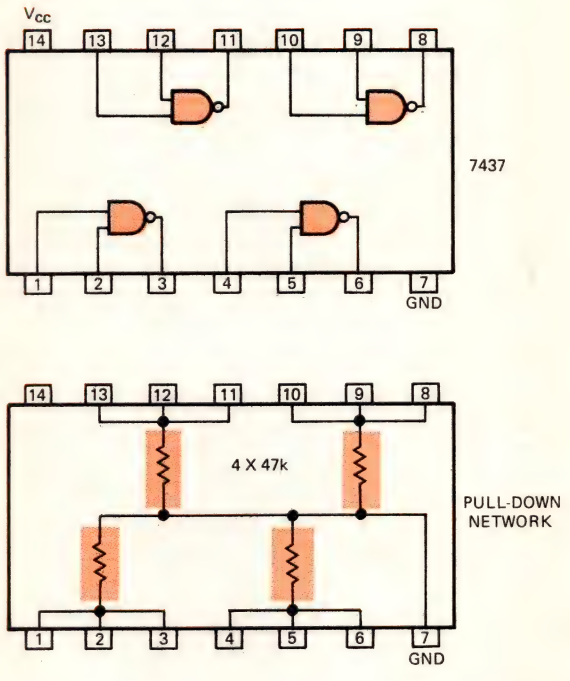


Fig 5—You can replace a 7437 inverter *with a feed-through pull-down network on a component platform.*

Disconnected TTL inverter inputs will float HIGH

provide that much capability, but many MOS LSI devices cannot.

If your driver cannot supply the 4 to 8 mA demanded of it in the logic-HIGH state, you can change the inverter to a CMOS device. Typically, the input-current demand of such a CMOS inverter is 10 pA; consider the absolute worst case to be 1 μA. To hold the input to the CMOS inverter in the logic-LOW condition, the pull-down resistor must keep that input below 30% of the supply voltage. A pull-down resistor of 1 MΩ proves quite sufficient for this purpose; any smaller value is acceptable.

You can now revise the 8741 control circuitry as shown in **Fig 4**. This example implements the CMOS-inverter solution, using 500-kΩ resistors as pull-downs. Now, removing power to the computer, unplugging the cable or even breaking a wire cannot cause the 8741 to destroy itself. This fix, however, solves only half the problem: What happens when the computer is powered-up and operating correctly; will everything work correctly?

Keep watch on the driving side

To guarantee that fail-safe conditions always prevail, you must examine your circuitry's driving side, too. In this example, the iSBC 80/20 uses an 8255A programmable peripheral interface to provide parallel-I/O capabilities. That component is an LSI device, and you can program its individual pins as either inputs or outputs, or use them bidirectionally.

The 8226 bidirectional buffers shown in **Fig 2** are a permanent part of the iSBC 80/20 circuitry and are controlled so that data can flow between the 8255A and the 8741 in either direction. Most of the 8255A's I/O lines appear at sockets, so you can insert 7437 inverting buffers there to provide output-driving capability, or install resistor termination networks to implement receiving.

The cassette controller uses three of the 8255's signals as outputs, so you could take the 7437 approach—if you are sure that the output of that driver is always LOW except when issuing the cassette controller a read or write command. This approach, of course, implies that the inputs to the 7437 (and hence the outputs of the 8255A to which they are connected) remain HIGH at all times when the controller is not in use. But do they?

When power is first applied to the iSBC 80/20, its 8255As are all reset so they can accept inputs—a fail-safe provision that prevents the production of spurious output signals. The 8255 lines thus appear to the 7437 inputs as a high-impedance state; the 7437 inputs then float HIGH, forcing the output signals to the controller into the benign near-ground state. So far, so good.

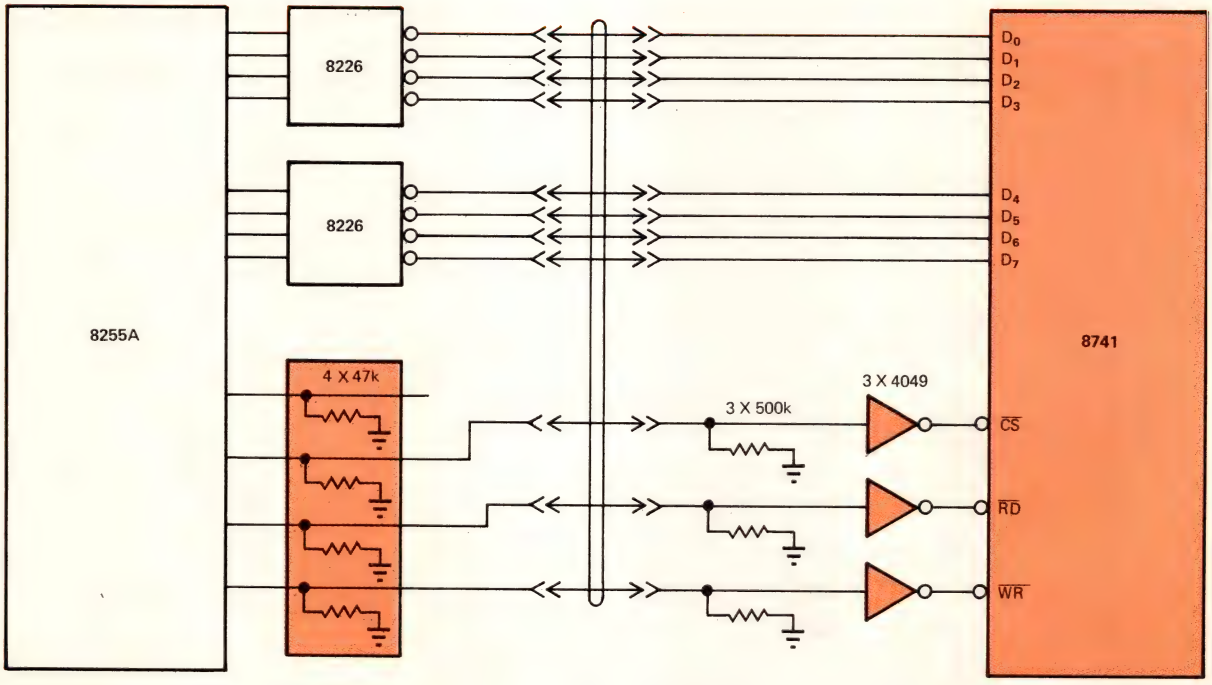


Fig 6—The final interface circuit *features fail-safe design that protects all components and functions within worst-case constraints.*

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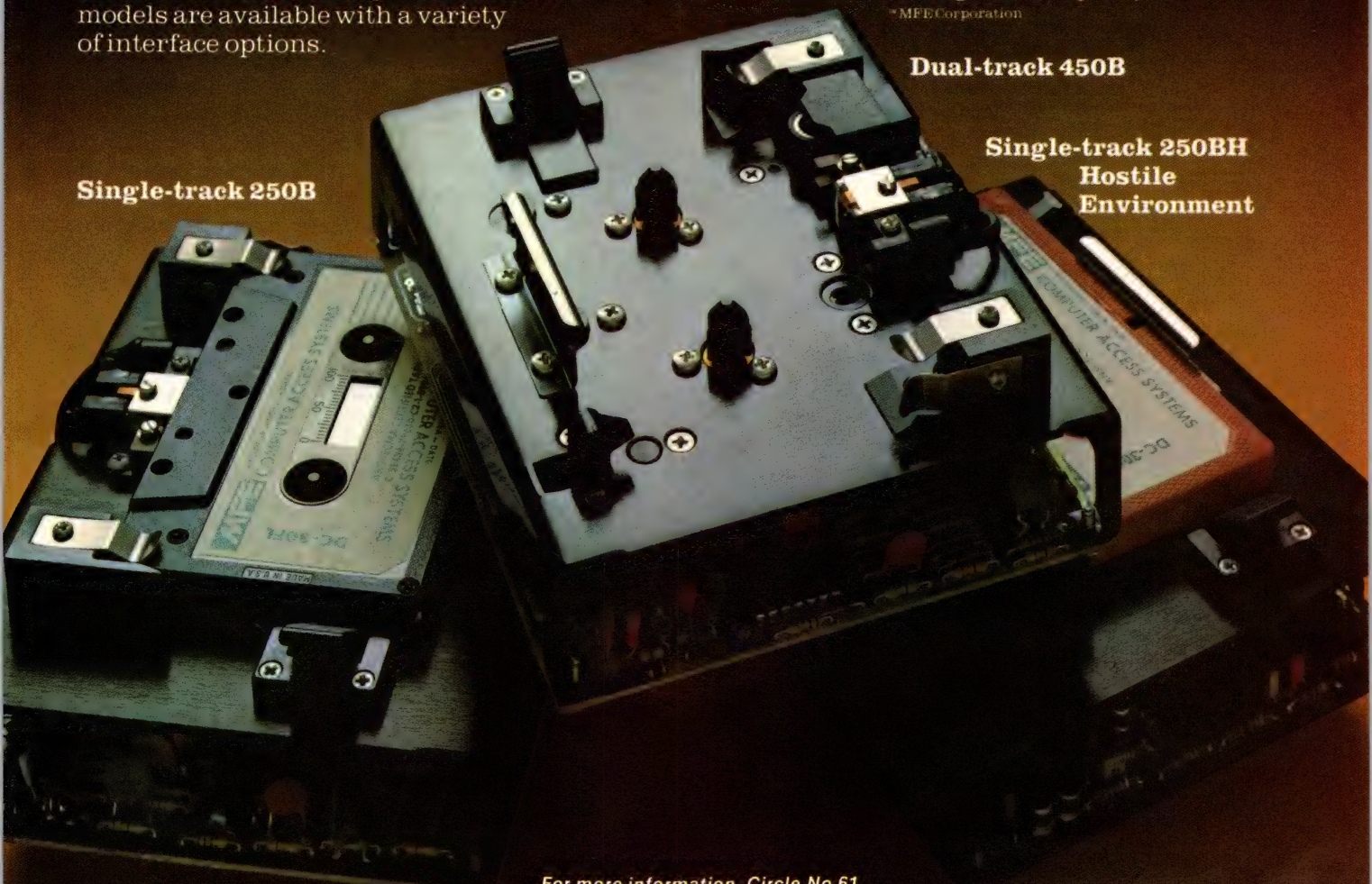
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CMOS inverters allow larger pull-down values

Programming the 8255A to turn selected lines into outputs enables the drivers and clears data latches inside the part. The very next instruction could set those latched data bits to all ONEs, but notice that for a short time the 7437 inputs are LOW. That state, of course, causes a glitch at the inputs to the 8741 controller circuitry—not long enough to damage the 8741, but (in a critical application) long enough to set some of the software inside it into action.

Use a network to simulate a 7437

True fail-safe operation, then, precludes using an inverter between the 8255A and the signal lines to the 8741 controller. So instead you can incorporate another pull-down resistor on each line.

Because the pinouts of the various commercially available resistor networks and the 7437 are all compatible, the pull-down network should conform to the same convention. Therefore, mount the resistors on a component platform with pins arranged to simulate a noninverting 7437 (**Fig 5**). Why can't you use the TTL version of a noninverting 7437, say a 7432? During computer reset, the inputs to such a TTL gate would float HIGH, thereby stimulating the 8741 into (incorrect) action.

Remembering the requirements of the pull-down resistor and examining the 8255A's worst-case current-source capability (200 μA), you'll find that the smallest permissible pull-down-resistor value is 12k. Because the resistor installed in the 7437 socket parallels the 500k resistor at the input to the remote inverter near the 8741, the smallest allowable resistor value on the iSBC 80/20 is 12.3k; 47k thus proves a convenient value.

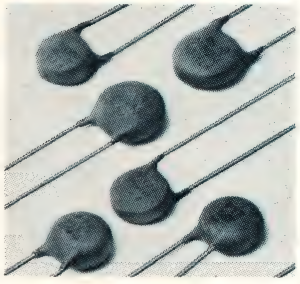
The resulting circuitry, as derived from the original configuration of **Fig 2**, appears in **Fig 6**. The remotely controlled peripheral device is now safe from harm during computer-power outage, when cables are completely or partially disconnected and during software initialization of the I/O path to the 8741. If power fails at the controller and the computer continues running, the drive signals see only the passive, high-impedance inputs of MOS circuitry.

Any remaining potential problems with fail-safe operation must lie within the controlling software. Clearly, this software could erroneously hold CS, RD and WR LOW at the 8741, but software checkout should catch this fault. If you require total fail-safe operation, create the $\overline{RD}$ input to the 8741 by complementing the $\overline{WR}$ line to that device. Note, however, that the 8741's sequential timing requirements prevent holding one or the other of those lines LOW while the chip select is inactive.

Rules for checking out and verifying software that can minimize these problems can be found in EDN's Software Design Course, June 5, 1978. In general, such problems appear more tractable once you adopt the foregoing hardware solutions to fail-safe interfacing. EDN

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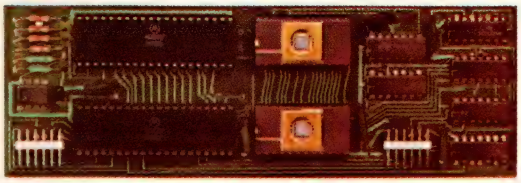
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High JFET gate input resistance serves well—if you can utilize it

Many designers try to take advantage of high JFET input resistance, only to be disappointed with the results. Understanding the reasons for this characteristic can help you make the most of a useful JFET property.

Ed Oxner, Siliconix Inc

One of the most widely known characteristics of JFETs—their high gate input resistance—is rarely specified on these devices' data sheets. But deriving this important parameter correctly from the information provided, and then applying it properly, are the keys to good JFET-circuit design.

The sampling-probe circuit shown in **Fig 1** is an example of a common JFET application. It utilizes as a source follower a 2N4868A n-channel device with a drain voltage of 30V and 1-mA drain current. Because this probe must sample 10V-rms signals on a high-impedance line and must not load the circuit under test, it must also exhibit a very high input resistance. Although the data sheet for the JFET used in the probe lists a 40V min breakdown voltage and a 250-pA max I_{GSS}, the probe-circuit design does not provide the required high input resistance.

Read between the lines on data sheets

To understand what's wrong with the circuit depicted in **Fig 1** (and it isn't the JFET itself that's at fault), consider the roots of the problem: the JFET is used incorrectly here because of any or all of the following faults:

- An improperly characterized data sheet
- An improper interpretation of the data sheet
- A misunderstanding of why a JFET exhibits a high gate input resistance.

You can't do much about the first fault except to make sure you know enough about these devices to recognize misleading data when you see it. For the most part, though, the latter two faults are the ones primarily responsible for incorrect JFET use.

If you design a circuit with at least 10-MΩ input resistance—such as the circuit in **Fig 1**—and the JFET data sheet lacks an input-resistance specification, you can extract an indication of this important parameter from another specification: gate current, which is inversely proportional to gate input resistance. Thus, JFETs with a 1-mA gate current provide an input resistance orders of magnitude lower than those with a 1-nA gate current.

However, unwary designers can then fall into the trap of using I_{GSS}—gate current with the drain terminal shorted to the source—as an indicator of input resistance. But I_{GSS} does not characterize the *operating* gate current—clearly, the JFET's high input resistance is not utilized

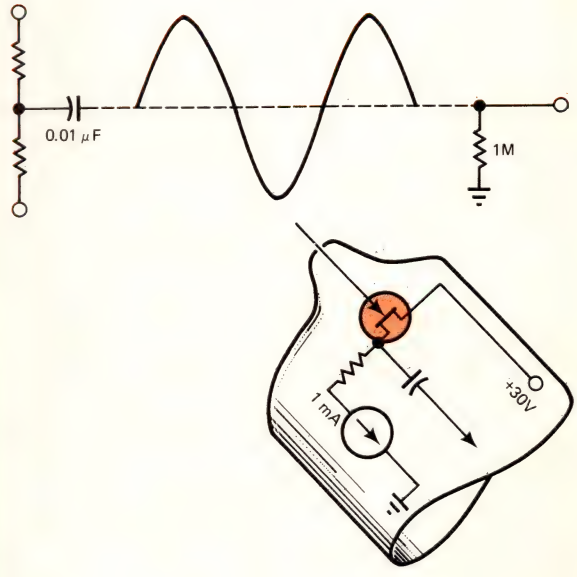


Fig 1—This JFET-input probe *is designed for failure.*

A mastery of JFET-circuit design begins with the data sheet

with the drain shorted to the source. Some years ago, the commonly accepted design procedure specified gate current at about 1/2 I_{GSS} for the desired drain-gate voltage. But this is a reasonable approximation only so long as the drain-gate voltage remains below the "I_G breakpoint."

The way out of this dilemma is to recognize that I_{GSS} represents nothing more than a measurement of reverse-bias diode current; with source shorted to drain, the channel becomes a cathode and the gate becomes an anode, and their interaction can be considered to constitute a simple diode. In this diode model, the reverse current typically stays small until it increases abruptly at some finite voltage—termed the reverse (avalanche) breakdown voltage—because of a process called avalanche multiplication.

Reverse current itself originates principally from the thermal generation of electron/hole pairs within the JFET's junction space-charge region. Avalanche multiplication then occurs when an electron within this space-charge region develops so much energy through increasing acceleration and subsequent collisions that other electron/hole pairs are created, resulting in rapidly increasing reverse current and rapidly decreasing gate input resistance.

JFETs act differently in a circuit

But an operating JFET differs from the preceding diode model because its drain is not shorted to the source and some finite drain current passes through the channel. Designers, furthermore, often overlook this drain current's effects upon gate current.

Illustrating the drain-current effect, **Fig 2** shows that gate current (I_G) increases linearly with drain current when the drain-gate voltage exceeds the I_G breakpoint; it also indicates that I_G increases exponentially with the drain-gate voltage (V_{DG}). (Raising the V_{DG} level increases impact ionization, thus increasing gate current.)

Replotting **Fig 2** as **Fig 3**, this time using drain-gate voltage as the primary variable, exposes the critical relationship between these two parameters. The tremendous difference between the I_G curves and the superimposed I_{GSS} characteristic reveals the folly of using I_{GSS} values above the I_G breakpoint to determine gate input resistance.

Yet another plot of the same JFET data yields additional information. **Fig 4** shows a comparison of two ratios: gate current to drain current (I_G/I_D) versus drain-gate voltage to drain-gate breakdown voltage (V_{DG}/BV_{DGO}). (**Fig 2** provides data for the current ratio and **Fig 3** furnishes voltage figures, with the drain-gate breakdown voltage

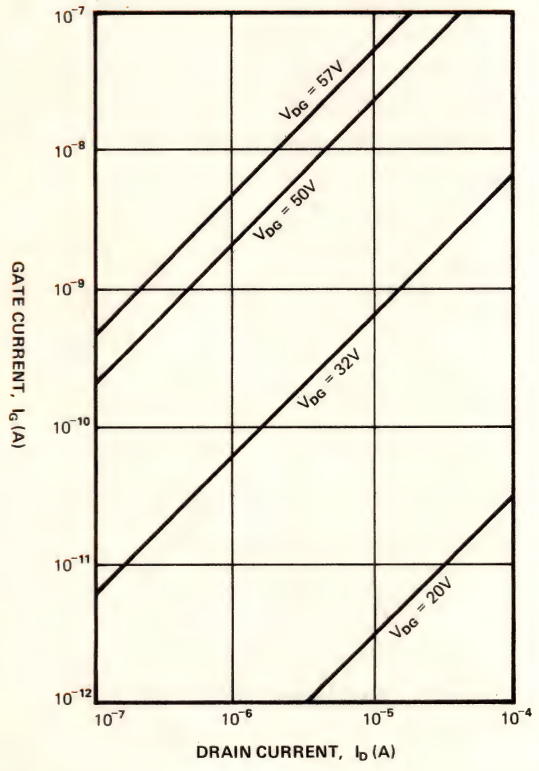


Fig 2—Gate current *is a linear function of drain current in the 2N4868A JFET.*

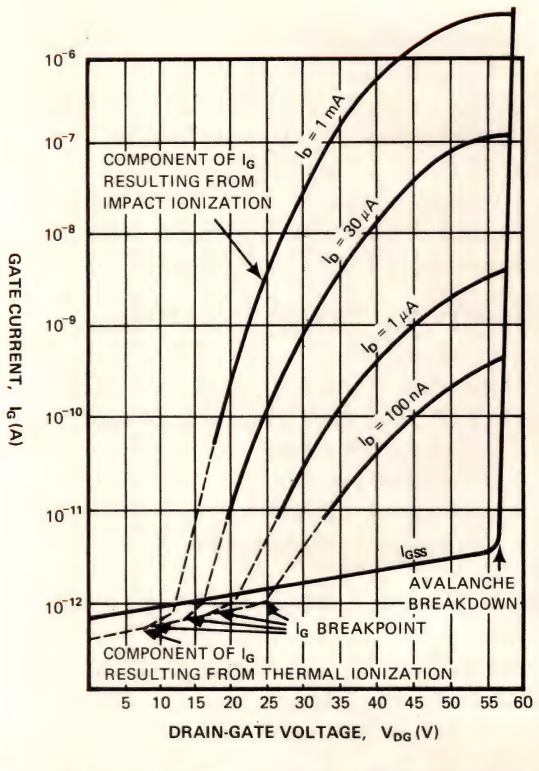


Fig 3—A plot of gate current versus drain-gate voltage *for the 2N4868A JFET shows why you can't use I_{GSS} values above the breakpoint to determine gate input resistance.*

established at the 57V I_{GSS} breakpoint.)

While **Fig 4** illustrates the dependence of current-ratio (leakage) characteristics on drain-gate voltage, it also simultaneously shows this parameter's independence from the type of n-channel JFET-fabrication technique employed: Curve A represents ratios from both a short-channel JFET and a long-channel, high-frequency JFET.

The problem of gate-leakage dependence on drain-gate voltage is a characteristic principally of n-channel devices, though. The p-channel JFET (represented by curve B in **Fig 4**) exhibits a response similar to that of the n-channel device, but because of this device's lower mobility and the resulting lower impact ionization, the p-channel curve is pushed out to a higher voltage and therefore presents less of a problem.

The data sheet's to blame

Although high gate input resistance is important in many applications including differential and operational amplifiers (as well as in the probe example here), the spec sheets for many dual JFETs—the 2N5045, 2N5452 and 2N5564 Series, for example—offer no hint of operating gate current. And among spec sheets for single n-channel JFETs, almost all fail to include this specification. Indirectly, the fault of omission lies with the JEDEC committee, but it is also more directly the fault of the manufacturer that

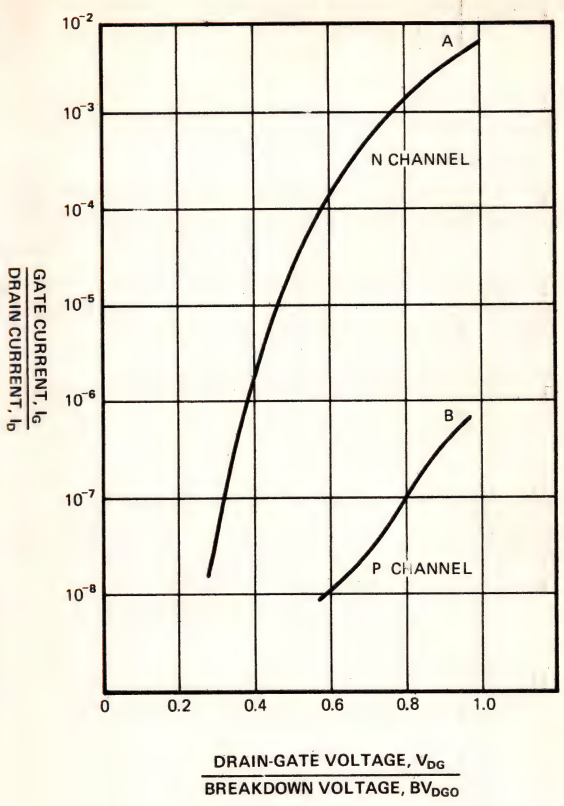


Fig 4—Normalized gate-current (leakage) variations *depend upon drain-gate voltage, plotted here for n- and p-channel JFETs.*

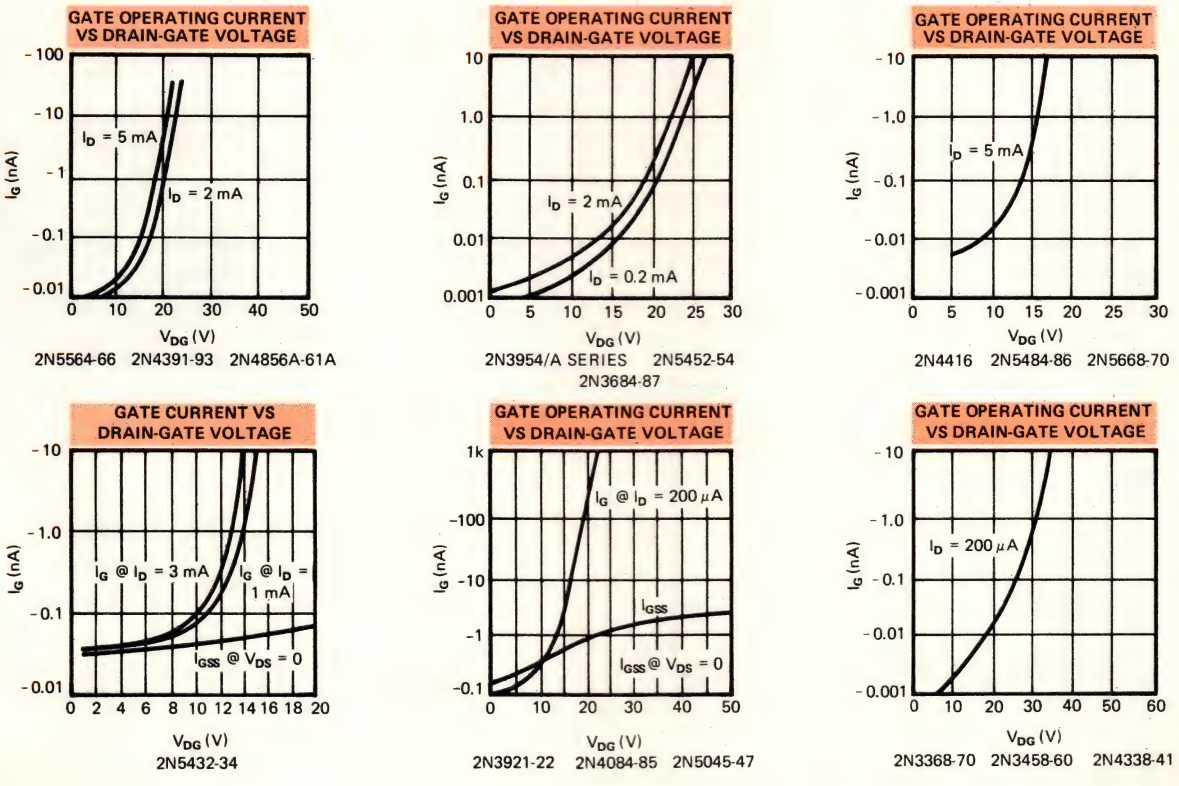


Fig 5—This collage of typical gate-current characteristics *shows what you might hope to see on a JFET data sheet.*

Some JFET gate characteristics can mislead the unwary

originally submitted JFET specifications for registration with this body.

If you have an application requiring high input resistance, you are thus confronted with something of a problem. If you don't care to tediously characterize selected JFETs yourself, you can only hope that the vendor has overridden the JEDEC format in its catalog and has included operating-gate-current figures. Alternatively, the vendor might offer a graphical presentation of gate-current data as in **Fig 5.** But however this information is presented, be aware that the operating gate-current characteristic for a particular JFET type can vary among manufacturers. Thus, if you change vendors—watch out.

Referring back to the example presented at the beginning of this article, you should understand by now why the probe doesn't perform as expected. The drain-gate voltage is a combination of the +30V bias supply and the peak negative potential of the 10V-rms signal appearing at the gate. The gate current, therefore, peaks to nearly 1 μA, and the input resistance falls short of the levels it could attain.

If you want to remedy this problem, one solution is to lower the bias voltage from +30V to +20V, thereby increasing the probe's input resistance to an acceptable level. You could, however, choose a better solution that permits high drain voltages and appreciable gate potentials without losing the JFET's unique high gate input resistance: Use a cascode circuit similar to the one shown in **Fig 6b.** In this arrangement, the input JFET's drain potential remains low because of its interaction with the piggyback JFET. **Fig 7** compares the gate currents (and thus the input-resistance performance) of the two circuits depicted in **Fig 6** and demonstrates the advantage of the dual-JFET configuration. **EDN**

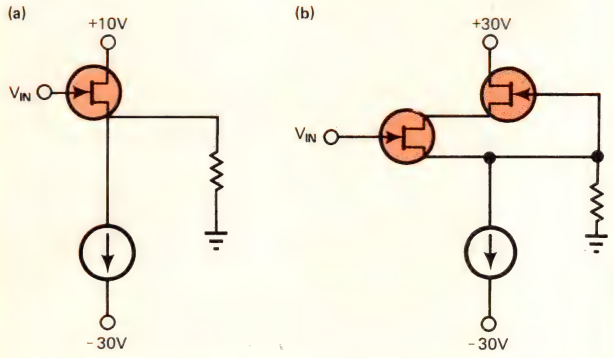


Fig 6—A single-JFET circuit (a) *offers simplicity, but it might not provide the high input resistance you want. A cascode dual-JFET alternative* ***(b)*** *solves the input-resistance problem.*

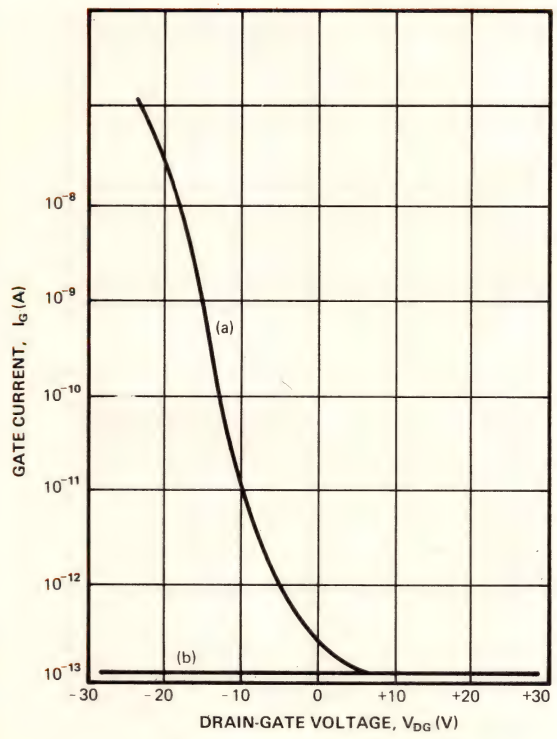


Fig 7—A plot of gate current for both circuits in Fig 6 *reveals that the dual-JFET one maintains its low gate current over a much wider operating-voltage range.*

Author's biography



Ed Oxner, manager of special-projects engineering at Siliconix Inc, Santa Clara, CA, spends most of his time developing VMOS technology, writing articles and giving seminars. He holds six patents and is a special representative of Overseas Crusades Inc. Ed acknowledges the support of Art Evans, who developed the basic theory of JFET gate-current breakpoint used in this article.

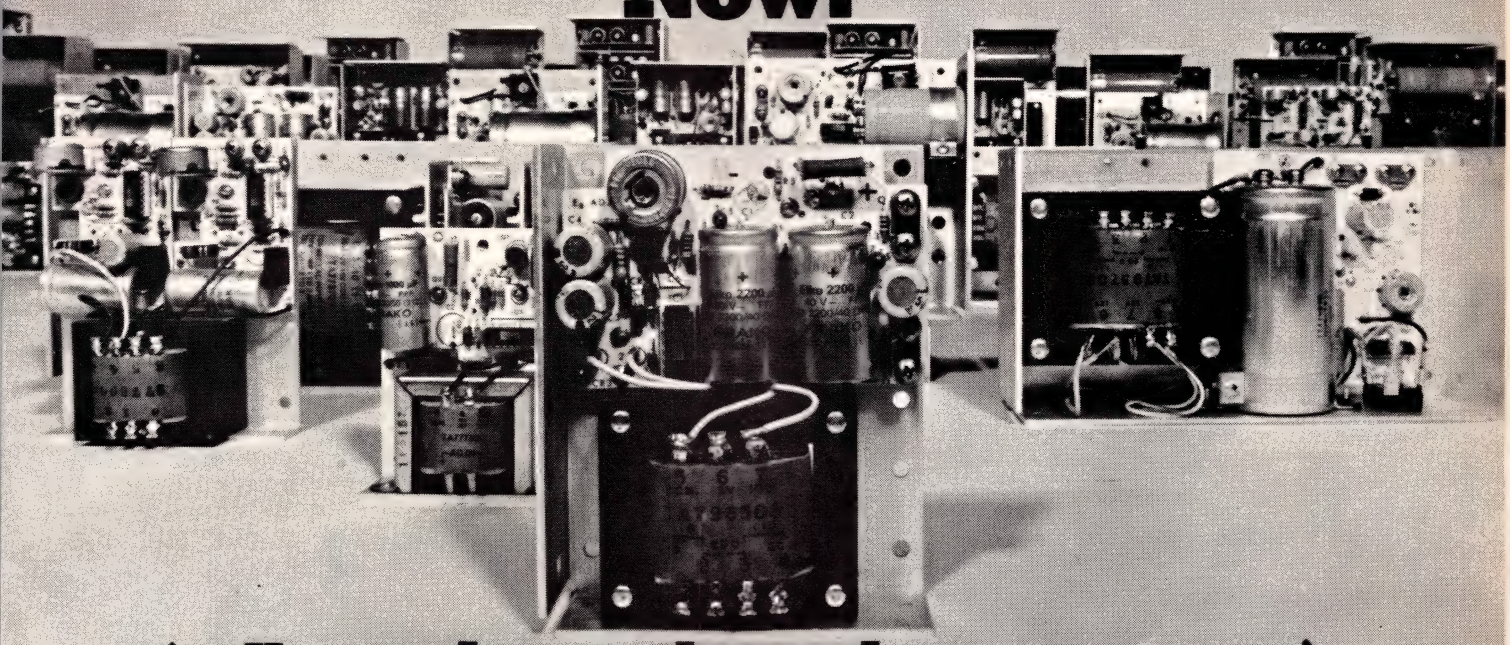
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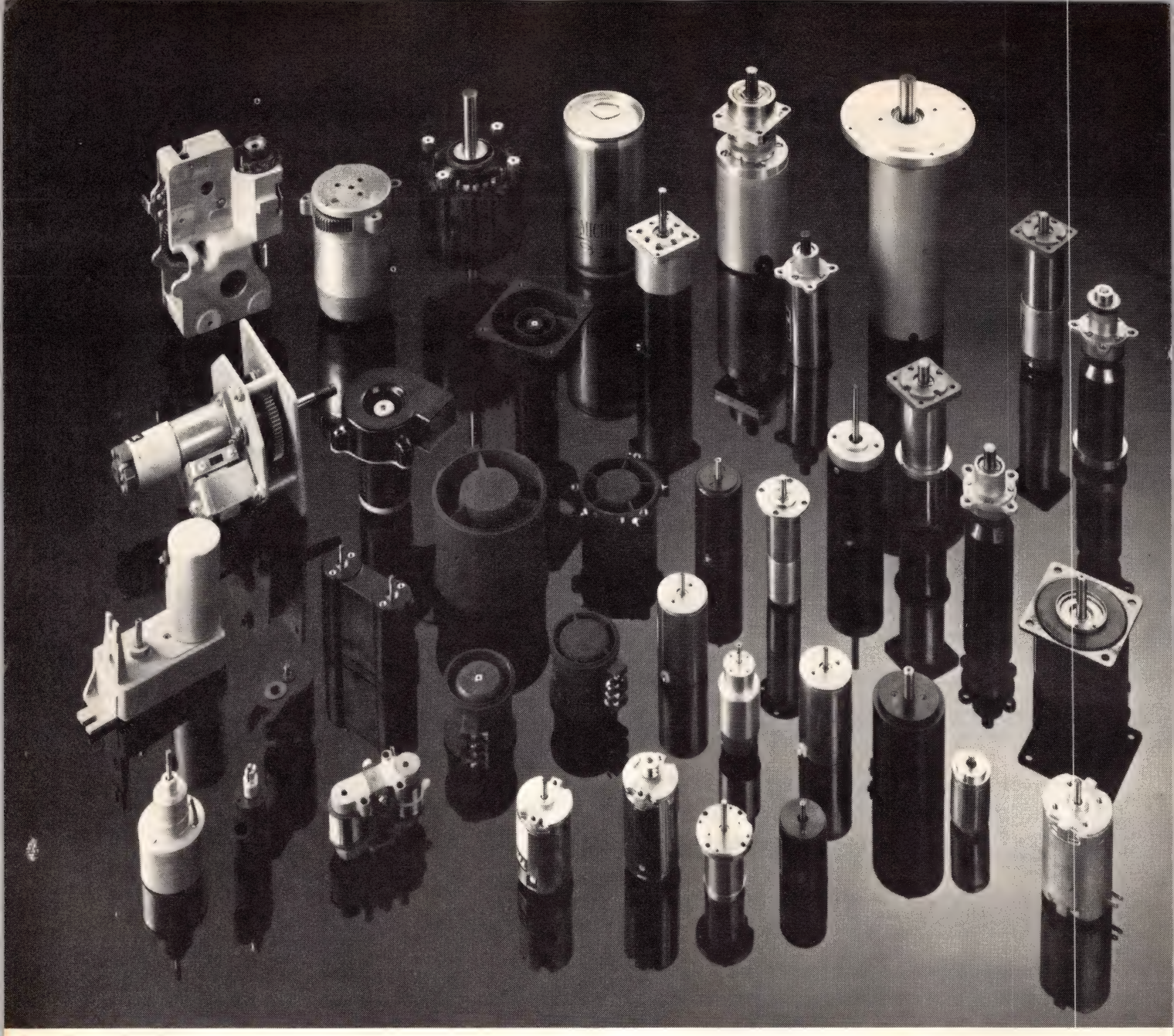
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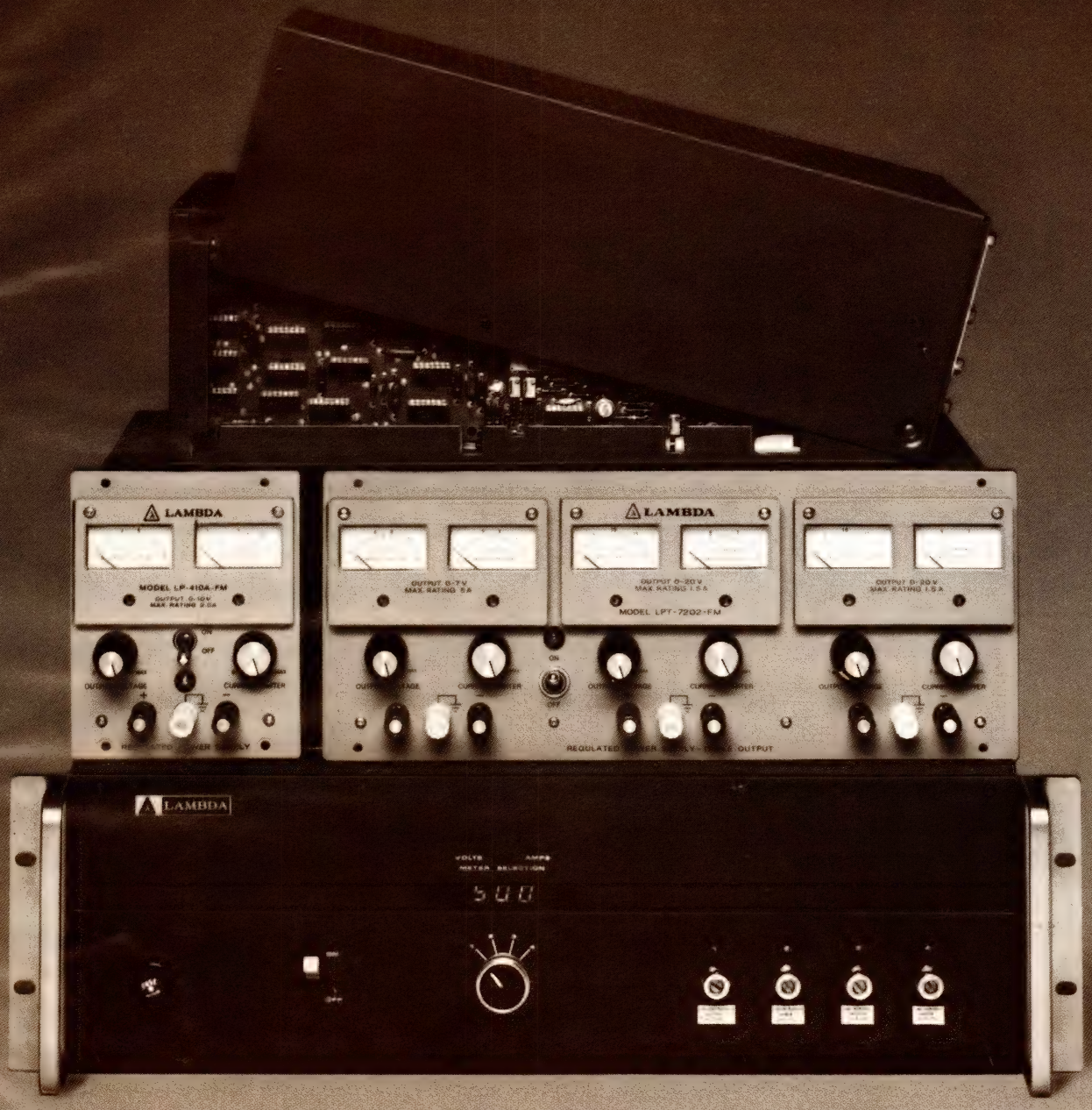
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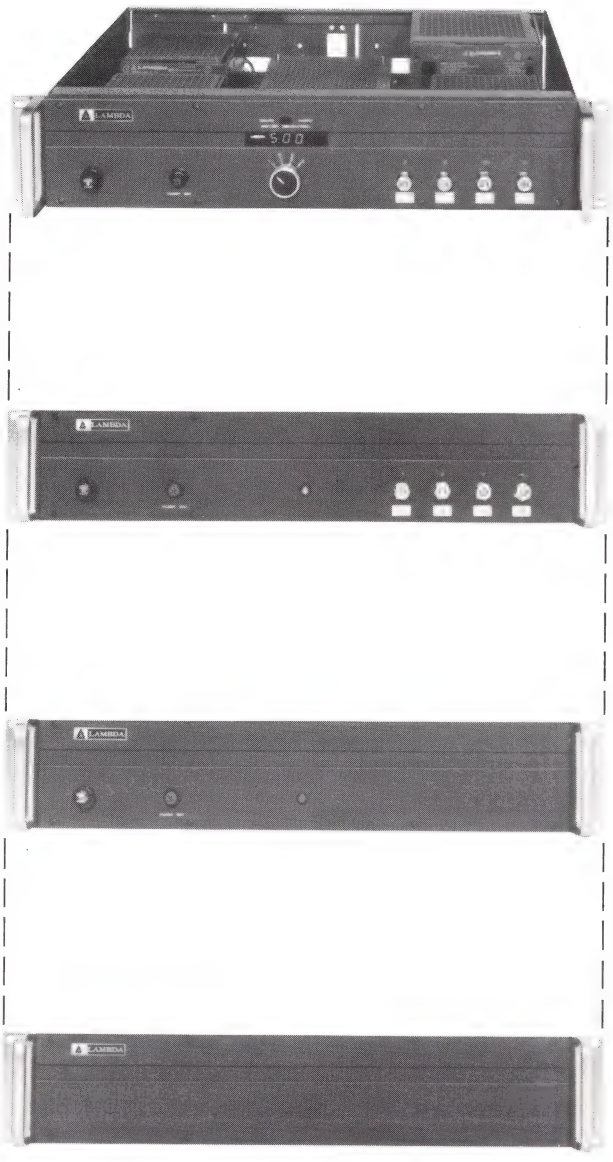


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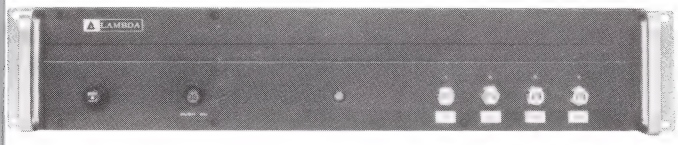
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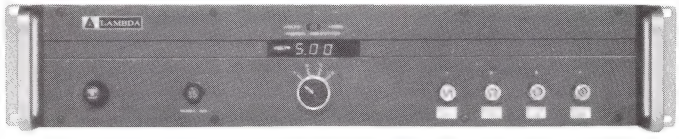


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Panel with on/off switch for AC input, pilot light and fuse plus voltage controls (up to 4 potentiometers provided). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

CONFIGURATION 4

Panel with on/off switch for AC input, and fuse, plus voltage controls (up to 4 potentiometers provided) and metering panel (up to 4 supplies monitored, monitoring up to 70A up to 99.9V per supply). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.



Example

Package L, Configuration 3 provides a completely wired, assembled, ready-to-use, custom power supply consisting of:

Two **LGS-6-12-OV-R** (12V @ 37.5A with built-in OV)	$642 ea.
One **LRA-16** rack adapter	95
Panel, AC on/off, indicator light, fuse, cables, voltage potentiometers and assembly labor . . .	170
Total Price	$1549

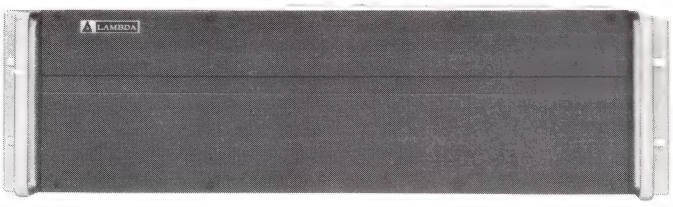
Call your nearest Lambda office for your custom system requirements.

PACKAGE SIZE K

5 3/16 x 19″ x 14″ • up to 8 outputs • and for any single output up to 150V, up to 135A

PACKAGE SIZE M

5 3/16″ x 19″ x 21″ • up to 8 outputs • and for any single output up to 150V, up to 220A



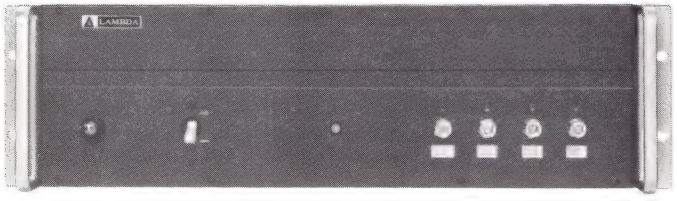
CONFIGURATION 1

Blank panel. Economical when power supply will be remotely controlled. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 2

Panel with on/off switch for AC input, pilot light and fuse. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.



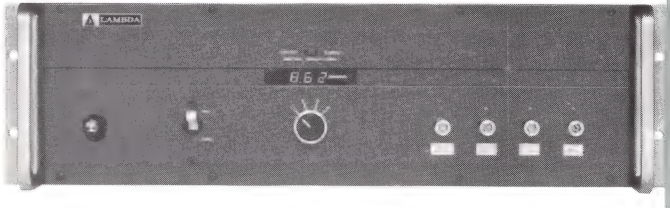


CONFIGURATION 3

Panel with on/off switch for AC input, pilot light and fuse plus voltage controls (up to 4 potentiometers provided). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

CONFIGURATION 4

Panel with on/off switch for AC input, and fuse, plus voltage controls (up to 4 potentiometers provided) and metering panel (up to 4 supplies monitored, monitoring up to 110A up to 99.9V per supply). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.



Example

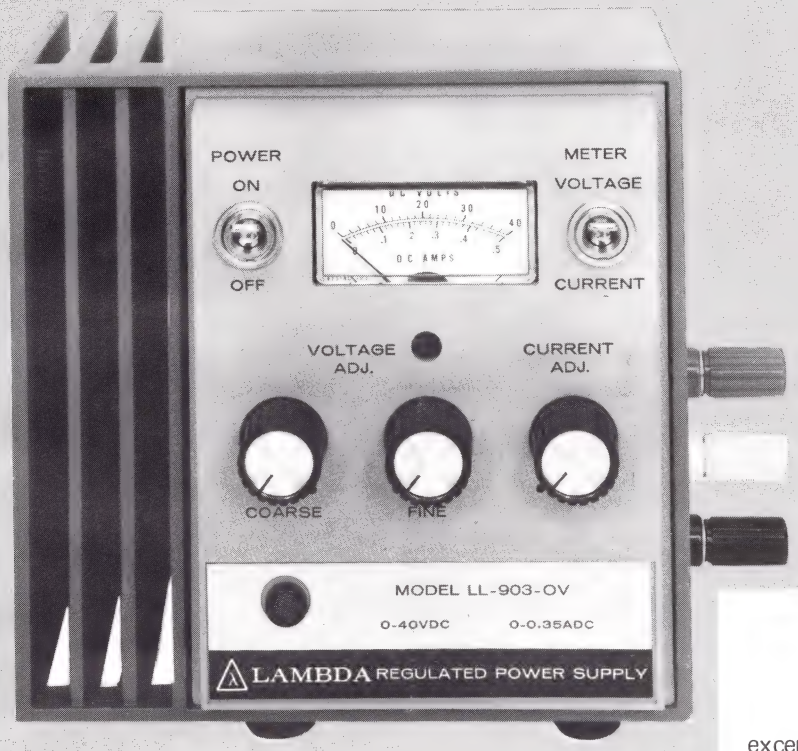
Package M, Configuration 4 provides a completely wired, assembled ready-to-use, custom power supply consisting of:

Two **LGS-5-5-OV-R** (5V @ 45A with built-in OV)	$476 ea.
Two **LGS-5-12-OV-R** (12V @ 24A with built-in OV)	476 ea.
One **LRA-17** rack adapter	95
Digital Meter, panel, AC on/off, indicator light fuse, voltage potentiometer, cables, and assembly labor	430
Total Price	$2429

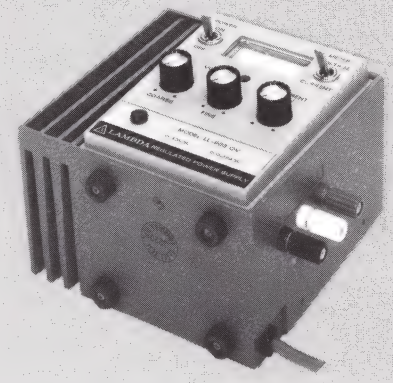
Call your nearest Lambda office for your custom system requirements.

LL SERIES
I-C REGULATED
BENCH POWER SUPPLIES

for general purpose laboratory use



LL Series I-C Regulated Power Supply



Multi-position lies flat or stands erect

LL SERIES BENCH TYPE SUPPLY
5⅝" x 5½" x 3⅞"

MODEL	ADJ. VOLT. RANGE VDC	CURRENT RANGE (1)	PRICE(2)
3 models with built-in tracking overvoltage protection			
LL-901-OV	0-10	0-1 amp	**$163**
LL-902-OV	0-20	0-0.65 amp	**163**
LL-903-OV	0-40	0-0.35 amp	**163**
LL-905	0-120	0-65 ma	**163**

REGULATION: Line: 0.01% + 1 mV Load: 4 mV

RIPPLE: 250 uV RMS

NOTES:

(1) Consult factory for operation at 400 Hz or temperatures above 50°C. Ratings apply 0-50°C.

(2) All prices and specifications subject to change without notice.

Outstanding Features

All-silicon DC power supply using integrated circuit to provide regulation system

except for input and output capacitors, rectifiers, and series regulation transistors

Regulation

line: 0.01% + 1 mV
load: 4mV

Ripple

250 uV RMS, 1 mV pk-pk

Convection cooled

Multi-position operation

lies flat or stands erect

Die-cast aluminum construction

Weight

less than 6 lbs.

No overshoot

on turn-on, turn-off or power failure

Adjustable current limiting

0 to 110 % of rating

Controls

course voltage adjust, fine voltage adjust, current adjust, ON/OFF switch, meter function switch

Built-in tracking overvoltage protection models available

SPECIFICATIONS OF LL SERIES

DC output
voltage ranges: 0-10V, 0-20V, 0-40V, 0-120V.

Regulated voltage
regulation, line . . . . . .0.01% + 1mV
regulation, load . . . . . .4 mV
ripple and noise . . . . . .250 uV RMS
1 mV pk-pk
temperature coefficient .(0.015% +
300 uV) /°C

AC input
line . . . . . 105-132 VAC 47-440 Hz (current ratings based on 57-63 Hz) derate current 10% for 50 Hz operation. 187-242 VAC, 205-265 VAC, 45-440 Hz, see "AC Input Option"
power . . . . . .LL-901-OV, 30 Watts; LL-902-OV, 32 Watts; LL-903-OV, 32 Watts; LL-905, 15 Watts

Ambient operating temperature range
continuous duty from 0° to + 50°C

Storage temperature range
-40°C to +85°C

Overload Protection
Electrical
external overload protection: automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for load as well as the power supply. Automatic current limiting is adjustable from 0-110% of rating.

Overvoltage protection
built-in tracking overvoltage protection on LL-901-OV, LL-902-OV and LL-903-OV.

Input connections
heavy-duty, 3-wire line cord provided.

Output connections
5-way binding posts on side panel.

Meter
dual function meter measures voltage or current output as selected by meter function switch on front panel.

Controls
DC output controls

course voltage adjust, fine voltage adjust and current adjust on front panel. On models LL-901-OV, LL-902-OV and LL-903-OV adjustment of voltage control allows overvoltage protector to track voltage output automatically.

Power
on-off switch on front panel

Meter
function switch to measure output voltage or current.

Multiposition operation
lies flat or stands erect

Physical data
Size
5 5/8"W x 5 1/2"H x 3 7/8"D

Weight
5 lbs. net, 7 lbs. ship

Accessories
pot covers. See catalog.

Options
AC input

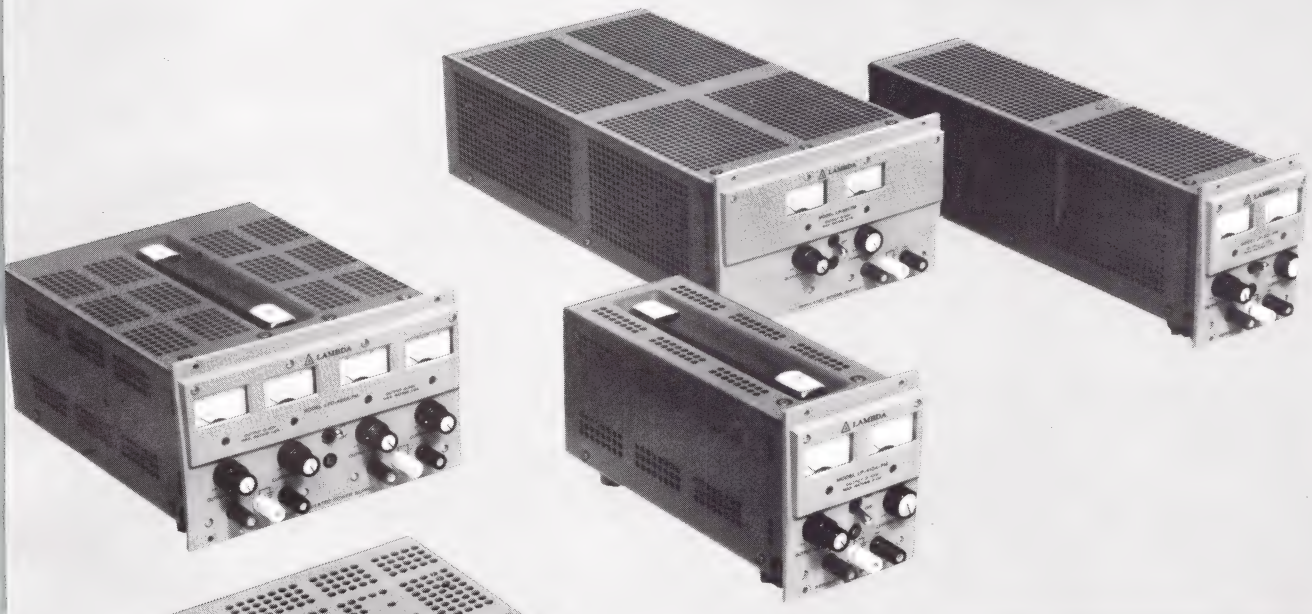
Add suffix:	For operation at:	Price
–V	187-242 VAC, 47-440 Hz	$20
–V1	205-265 VAC, 47-440 Hz	$20

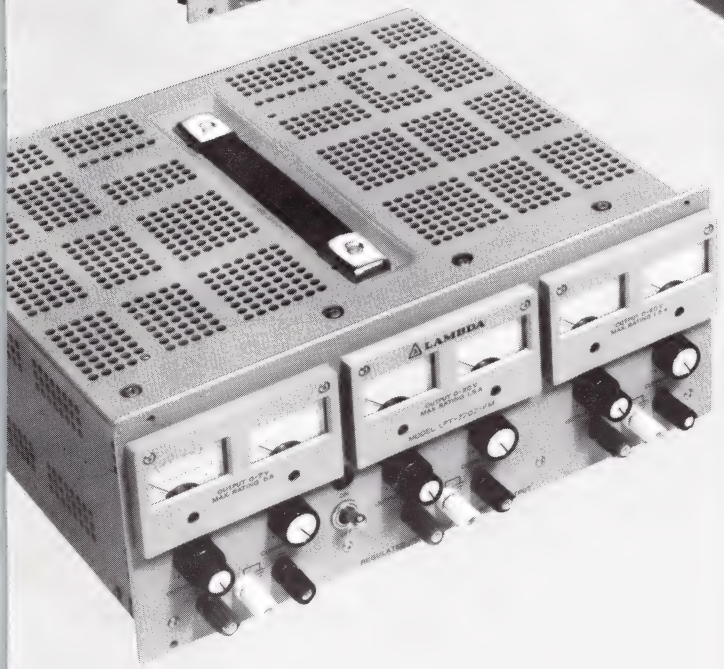
Derate current 10% for 50 Hz operation

Guaranteed for 5 years
5-year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

LP SERIES SINGLE-OUTPUT POWER SUPPLIES
LPD SERIES DUAL-OUTPUT POWER SUPPLY
LPT SERIES TRIPLE-OUTPUT POWER SUPPLY

for general purpose laboratory and test equipment use.





Widest selection of laboratory supplies with big-system features and capabilities for bench or rack use.

Outstanding Features

Designed for both bench and rack use.
Convection cooled

no blowers, no external heat sinks

Series/parallel operation
Continuously variable
Remotely programmable
Remote sensing
Constant voltage/constant current
Designed to meet RFI

per MIL STD 826A

Completely protected

Short circuit proof; continuously adjustable automatic current limiting

No overshoot

on turn-on, turn-off or power failure

Features of dual and triple output models

6 models with independent DC outputs offer widest choice

up to ±250 VDC, up to 5 Amps. Either output may be plus or minus, or both outputs may be plus or minus.

Series/parallel operation

of outputs yields two times the voltage or two times the current – up to 500 Volts or up to 3.4 Amps.

Auto series/auto parallel (master-slave)

permits tracking to a common reference

Separate meters

provide simultaneous monitoring of both voltage and current.

LPT SERIES TRIPLE OUTPUT MODEL

MODEL	REGULATION[5]	RIPPLE (RMS)	VOLTAGE RANGE (VDC)[4]	MAX CURRENT, AMPS AT AMBIENT OF: [1] 30°C	40°C	50°C	60°C	DIMENSIONS	[2] Price
LPT-7202-FM	0.01% + 1 mV	500 uV	0-7	5.0	4.5	4.0	3.5	5 3/16" x 12 1/2" x 11"	$706
			0-20	1.5	1.35	1.2	1.0		
			0-20	1.5	1.35	1.2	1.0		

LPD SERIES DUAL OUTPUT MODELS

MODEL	REGULATION[4]	RIPPLE (RMS)	VOLTAGE RANGE [3] Per Output / Outputs in Series VDC	MAX CURRENT, AMPS AT AMBIENT OF: [1] Per Output / Outputs in Parallel 30°C	40°C	50°C	60°C	DIMENSIONS	[2][3] Price
*LPD-421A-FM	0.01% + 1 mV	500 uV	0- ±20/0-40	1.7/3.4	1.5/3.0	1.3/2.6	0.9/1.8	5 3/16" x 8 3/8" x 10 3/32"	$480
*LPD-422A-FM	0.01% + 1 mV	500 uV	0- ±40/0-80	1.0/2.0	0.85/1.7	0.7/1.4	0.55/1.1	5 3/16" x 8 3/8" x 10 3/32"	480
*LPD-423A-FM	0.01% + 1 mV	500 uV	0- ±60/0-120	0.7/1.4	0.6/1.2	0.5/1.0	0.4/0.8	5/3/16" x 8 3/8" x 10 3/32"	480
LPD-424A-FM	0.01% + 1 mV	500 uV	0- ±120/0-240	0.38/0.76	0.32/0.64	0.26/0.52	0.20/0.40	5 3/16" x 8 3/8" x 10 3/32"	480
LPD-425A-FM	0.01% + 1 mV	1 mV	0- ±250/0-500	0.13/0.26	0.12/0.24	0.11/0.22	0.10/0.20	5 3/16" x 8 3/8" x 10 3/32"	572

LP SERIES SINGLE OUTPUT MODELS

0-10 VOLTS

MODEL	REGULATION[5]	RIPPLE (RMS)	MAX CURRENT AMPS AT AMBIENT OF: [1] 30°C	40°C	50°C	60°C	DIMENSIONS	[2][3] Price
*LP-410A-FM	0.01% + 1 mV	500 uV	2.0	1.8	1.6	1.4	5 3/16" x 4 3/16" x 10"	$269
*LP-520-FM	0.01% + 1 mV	500 uV	5.0	4.7	4.3	3.7	5 3/16" x 4 3/16" x 15 1/2"	332
*LP-530-FM	0.01% + 1 mV	500 uV	10.0	9.0	8.0	7.0	5 3/16" x 8 3/8" x 15 5/8"	480

0-20 VOLTS

*LP-411A-FM	0.01% + 1 mV	500 uV	1.2	1.1	1.0	0.8	5 3/16" x 4 3/16" x 10"	$269
*LP-521-FM	0.01% + 1 mV	500 uV	3.3	3.0	2.6	2.3	5 3/16" x 4 3/16" x 15 1/2"	332
*LP-531-FM	0.01% + 1 mV	500 uV	5.7	5.3	4.7	4.0	5 3/16" x 8 3/8" x 15 5/8"	463

0-40 VOLTS

*LP-412A-FM	0.01% + 1 mV	500 uV	1.0	0.90	0.80	0.60	5 3/16" x 4 3/16" x 10"	$269
*LP-522-FM	0.01% + 1 mV	500 uV	1.8	1.6	1.4	1.2	5 3/16" x 4 3/16" x 15 1/2"	332
*LP-532-FM	0.01% + 1 mV	500 uV	3.0	2.9	2.7	2.3	5 3/16" x 8 3/8" x 15 5/8"	463

0-60 VOLTS

*LP-413A-FM	0.01% + 1 mV	500 uV	0.45	0.41	0.37	0.33	5 3/16" x 4 3/16" x 10"	$269
*LP-523-FM	0.01% + 1 mV	500 uV	0.9	0.8	0.7	0.6	5 3/16" x 4 3/16" x 15 1/2"	338
*LP-533-FM	0.01% + 1 mV	500 uV	2.4	2.2	2.1	1.8	5 3/16" x 8 3/8" x 15 5/8"	516

0-120 VOLTS

LP-414A-FM	0.01% + 1 mV	500 uV	0.20	0.18	0.16	0.12	5 3/16" x 4 3/16" x 10"	$297
LP-524-FM	0.01% + 1 mV	500 uV	0.5	0.45	0.4	0.35	5 3/16" x 4 3/16" x 15 1/2"	378
LP-534-FM	0.01% + 1 mV	500 uV	1.2	1.0	0.9	0.8	5 3/16" x 8 3/8" x 15 5/8"	572

0-250 VOLTS

LP-415A-FM	0.01% + 1 mV	500 uV	80 mA	72 mA	65 mA	60 mA	5 3/16" x 4 3/16" x 10"	$332

NOTES:

* Overvoltage protection available as an accessory. Each output requires separate OV accessory — add $35.00 for each output.

See page 153.

(1) Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.

(2) All prices subject to change without notice.

(3) LPD, LPT Series models require one LH-OV for each output.

(4) See next page for full specifications

SPECIFICATIONS OF LP, LPD & LPT SERIES

DC output
voltage ranges shown in tables.

Regulated voltage

regulation (line or load)	0.01% + 1mV for line variations from 105-132 VAC or for load changes from no load to full load.
current range	as shown in table
remote programming resistance	200 ohms/volt nominal
remote programming voltage	volt per volt
ripple and noise	500uV RMS, 1.5mV pk-pk (either plus or minus terminal grounded.) LPD-425-A-FM model only 1mV RMS, 3mV, pk-pk.
Temperature coefficient	(0.015% + 0.3mV)/°C-LP, LPT models (0.015% + 0.5mV)/°C-LPD models

Constant current
(current regulated line and load)

Automatic crossover

voltage range	as shown in tables
current range	min: 45mA or 1% whichever is greater (LP-530-FM — LP-534-FM, LPT models only) all other LP models and LPD models 5mA or 1% whichever is greater. max: as shown in tables.
regulation (line or load)	less than 0.2% or 5mA whichever is greater.

AC input
105-132 VAC; 47-440 Hz. Ratings based on 57-63 Hz.
187-242 VAC; 205-265 VAC. See "AC Input Option."

Ambient operating temperature range
continuous duty from 0° to +60°C

Storage temperature range
-55°C to +85°C

Overload protection
Thermal
Thermostat, automatic reset.

Electrical

external overload protection	adjustable, automatic electronic current limiting, settable to 105% of rated current.
internal failure protection	provided by fuse

Input and output connections
covered terminal block on rear of chassis; five-way binding posts on front panel. On LPD, LPT Models one set of five-way posts is provided for each output.

Meters
voltmeter and ammeter. For LPD, LPT Models, each output has a separate voltmeter and ammeter.

Controls
DC output controls
coarse and fine voltage and coarse and fine current adjust provided on front panel of all LPD, LPT models for each output. On all other LP models coarse and fine voltage adjust and single current adjust controls are provided.

Power
on-off switch, front panel.

Remote sensing
provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

Physical data

Series	Weight Lbs net	Weight Lbs ship	Size (Inches)
LP410A	7	10	5 3/16 x 4 3/16 x 10
LP520	14	18	5 3/16 x 4 3/16 x 15 1/2
LP530	25	30	5 3/16 x 8 3/8 x 15 5/8
LPD	13	16	5 3/16 x 8 3/8 x 10 3/32
LPT	24	29	5 3/16 x 12 1/2 x 11

Panel finish
tan glass-filled, flame-retardant nylon panels.

Accessories
rack adapters, overvoltage protectors, pot covers, blank panels.
See page 153.

Options
Ac input

Add suffix	for operation at:	Price Qty 1-14	Price Single Model Qty 15 & up	Price Mixed Model Qty 15 & up
–V	187-242 VAC 47-440 Hz	12% or $30*	10%	12% or $30*
–V1	205-265 VAC 47-440 Hz	12% or $30*	10%	12% or $30*

*Whichever is greater

For 50 Hz operation derate current 10% on all models

Fungus proofing
add suffix "-R" to model number and add 10% or $25.00 to the price (whichever is greater).

Guaranteed for 5 years
5-year guarantee includes labor as well as parts. Guarantee applies, to operation at full published specifications at end of 5 years.

LE SERIES
20KHz WIDE RANGE
SWITCHING POWER SUPPLIES

For use in laboratory, systems and test equipment



45% smaller by volume and 46% more amps per dollar than an equivalent SCR switching power supply.

Guaranteed 5 Years

OUTPUT RATINGS FOR LES-F SERIES

MODEL	REGULATED OUTPUT VOLTAGE	MAX. OUTPUT CURRENT AT 40°C	50°C	60°C	71°C	PRICE
LES-F-01-0V	0 – 7.5V	100A	83A	66A	47.5A	$1200
LES-F-02-0V	0 – 18V	47.5A	41A.	32.5A	23.5A	1100
LES-F-03-0V	0 – 36V	24A	20.4A	16.5A	12A	1000
LES-F-04-0V	0 – 60V	15A	12.8A	10.3A	7.5A	1200

Note: Maximum output current applies over entire output voltage range.

Outstanding Features

Designed to meet military environment MIL-STD-810C

Digital Meter Readout

Convection cooled, no fans or blowers

Constant voltage/constant current

Overvoltage protection — bui in on all models

SPECIFICATIONS OF LE SERIES

DC output and rating
Refer to the table.

Regulated voltage
regulation line ..... 0.02% + 2 mv for line variations from 105 to 132 vac (or 187 to 242 vac on 'V' options, 205 to 265 vac on 'VI' options).
regulation load ..... 0.02% + 2 mv (LES-F-01, 02)
0.02% + 4 mv (LES-F-03, 04) for load variations from 0 to full load.
remote programming resistance ..... 200 Ω/volt nominal
remote programming voltage volt/volt
ripple and noise ..... 10 mv-rms; 50 mv pp for LES-F-01
15 mv-rms; 100 mv pp for LES-F-02,03,04
temperature coefficient ..... (0.02% + 50 μv)/°C

Constant current
(current regulated line and load)
automatic crossover.
voltage range ..... As shown in table.
current range ..... 5% to full load current.
regulation line ..... 0.5% + 50 mA (LES-F-01, 02)
0.5% + 20 mA (LES-F-03, 04) line variations from 105 to 132 vac (or 187 to 242 vac on 'V' opts, 205 to 265 vac on 'VI' opts).
regulation load ..... 0.5% of $I_{(max)}$ for load changes from 5% to rated DC voltage.

AC input
line ..... 105-132 vac (47-63 Hz) standard input (derate output current by 5% at 50 Hz)
power ..... 1250 watts max at 0.6 P.F. at maximum output voltage, nominal line.
efficiency ..... Minimum 60% at maximum output voltage.
soft start circuit ..... Limits inrush current at turn on to 200% of full load peak current.
input current ..... 25A rms max.

Ambient operating temperature
Continuous duty from 0°C to 71°C with appropriate deratings (40°C to 71°C—see table).

Storage temperature range
−55°C to +85°C

Overload protection
Thermal
By self resetting thermostat
Electrical
External overload protection—adjustable, automatic, electronic current limiting circuit limits output current to preset value. Current limiting settability to 105% of rated current via front panel adjust.

Overvoltage protection
Built in, adjustable overvoltage protection standard on all sets. When preset voltage is exceeded, the overvoltage protector crowbars the output and removes the inverter drive. See table for OV range on each unit.

OVERVOLTAGE PROTECTION ADJUSTABLE RANGES - LES-F SERIES.

MODEL	V_{OUT}	ADJUSTABLE OVERVOLTAGE PROTECTOR RANGE	
		V_{OV}(min)	V_{OV}(max)
LES-F-01-0V	0 – 7.5VDC	3V	10V
LES-F-02-0V	0 – 18VDC	6V	24V
LES-F-03-0V	0 – 36VDC	9V	47V
LES-F-04-0V	0 – 60VDC	12V	70V

EMI
Conducted EMI conforms to MIL-I-6181D.

Cooling
Convection cooled—no fans or blowers.

Input and output connections
Heavy duty barrier strip and output studs on rear of chassis.

Meters
Digital panel meter standard on all sets monitors output voltage/current by means of a volt/amp selector switch.

Controls
DC output controls
coarse and fine voltage adjust and coarse current adjust on front panel.
Overvoltage protection
overvoltage trip point set by screwdriver adjust on front panel.
Power
on-off switch on front panel.

Remote sensing
Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

Fungus proofing
All units are rendered fungi inert.

Options
AC input

Add Suffix	For Operation at:	Price Qty. 1-14	Price Mixed Models Qty. 15 and up	Price Single Model Qty. 15 and up
-V	187-242 VAC (47-63 Hz*) (derate current 10%)	12%	12%	10%
-V1	205-265 VAC (47-63 Hz*)	12%	12%	10%

*derate 5% at 50 Hz operation

Accessories
Chassis slides (KHT-34-012). See catalog.

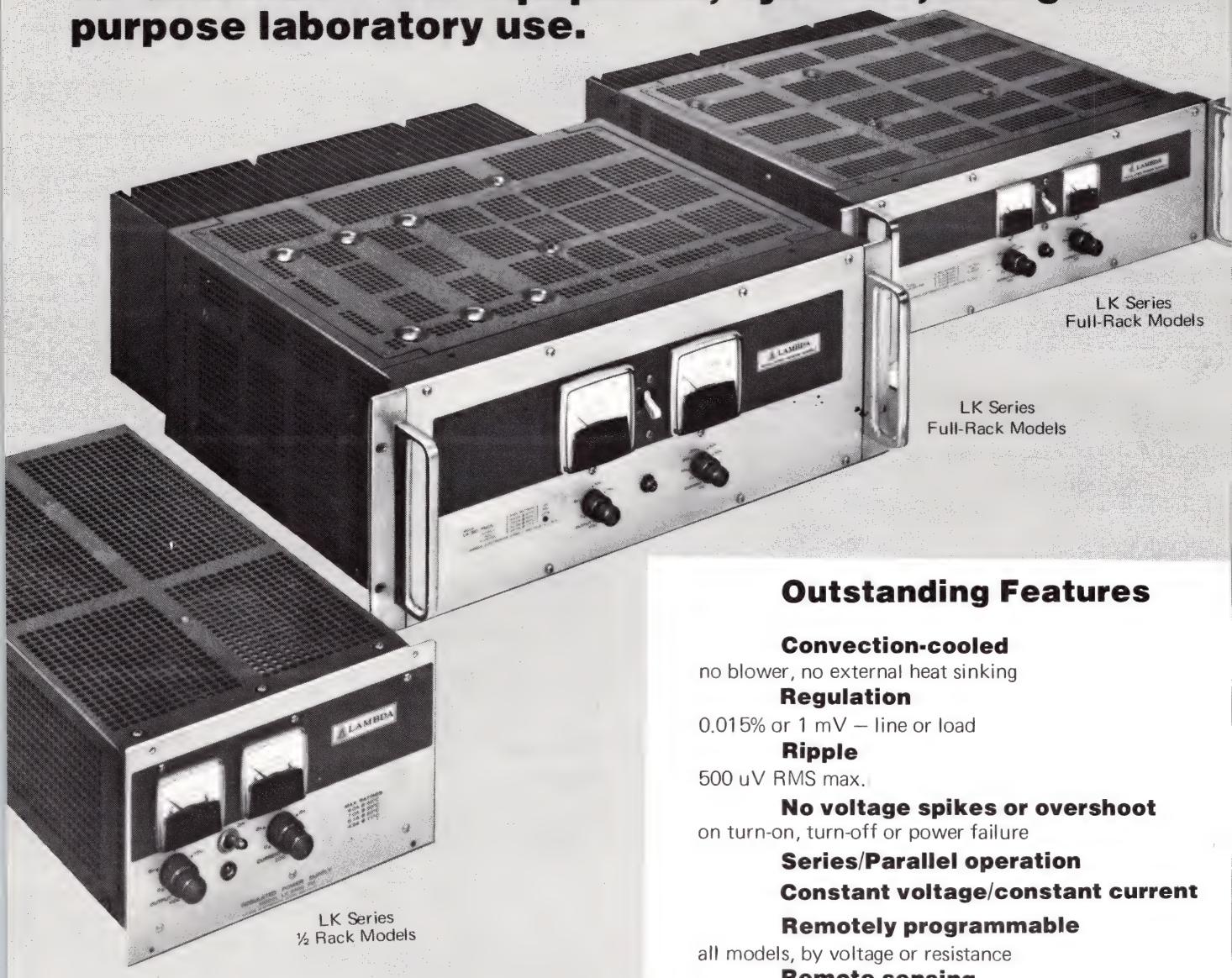
Weight
net: 40 lbs
ship: 50 lbs

Size
3 1/2" x 19 x 16 1/2" (H x W x D)

Guaranteed for 5 years
5 year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

LK SERIES HIGH CURRENT POWER SUPPLIES

for automatic test equipment, systems, and general purpose laboratory use.



LK Series
Full-Rack Models

LK Series
Full-Rack Models

LK Series
½ Rack Models

All silicon convection-cooled power supplies
for bench or rack use

Outstanding Features

Convection-cooled
no blower, no external heat sinking

Regulation
0.015% or 1 mV — line or load

Ripple
500 uV RMS max.

No voltage spikes or overshoot
on turn-on, turn-off or power failure

Series/Parallel operation

Constant voltage/constant current

Remotely programmable
all models, by voltage or resistance

Remote sensing
eliminates effect of power output lead resistance on DC regulation

Meet mil, environment specs.
vibration: MIL-T-4807A
shock: MIL-E-4970A Proc. 1 &2
humidity: MIL-STD-819 Meth. 507
temp. shock: MIL-E-5272C (ASG) Proc. 1
Altitude: MIL-E-4970A (ASG) Proc. 1
marking: MIL-STD-130
quality: MIL-Q-9858

LK SERIES

Three high current, all convection-cooled power packages
0-20, 0-36, 0-60 VDC and up to 66 Amps.

0-20 VOLTS

MODEL	REGULATION	RIPPLE (RMS)	MAX. CURRENT, AMPS AT AMBIENT OF:(1) 40°C	50°C	60°C	71°C	DIMENSIONS	PRICE (2)
LK-340-A-FM	0.015% or 1 mV	500 uV	8.0	7.0	6.1	4.9	5 3/16" x 8 3/8" x 16"	**$ 601**
LK-341-A-FM	0.015% or 1 mV	500 uV	13.5	11.0	10.0	7.7	5 3/16" x 8 3/8" x 16"	**779**
LK-350-FM	0.015% or 1 mV	500 uV	35.0	31.0	26.0	20.0	5 3/16" x 19" x 16 1/2"	**1082**
LK-360-FM*	0.015% or 1 mV	500 uV	66.0	59.0	50.0	40.0	7" x 19" x 18 1/2"	**1683**

0-36 VOLTS

LK-342-A-FM	0.015% or 1 mV	500 uV	5.2	5.0	4.5	3.7	5 3/16" x 8 3/8" x 16"	**$ 601**
LK-343-A-FM	0.015% or 1 mV	500 uV	9.0	8.5	7.6	6.1	5 3/16" x 8 3/8" x 16"	**779**
LK-351-FM	0.015% or 1 mV	500 uV	25.0	23.0	20.0	15.0	5 3/16" x 19" x 16 1/2"	**1082**
LK-361-FM*	0.015% or 1 mV	500 uV	48.0	43.0	36.0	30.0	7" x 19" x 18 1/2"	**1683**

0-60 VOLTS

LK-344-A-FM	0.015% or 1 mV	500 uV	4.0	3.5	3.0	2.5	5 3/16" x 8 3/8" x 16"	**$ 653**
LK-345-A-FM	0.015% or 1 mV	500 uV	6.0	5.2	4.5	4.0	5 3/16" x 8 3/8" x 16"	**779**
LK-352-FM	0.015% or 1 mV	500 uV	15.0	14.0	12.5	10.0	5 3/16" x 19" x 16 1/2"	**1167**
LK-362-FM*	0.015% or 1 mV	500 uV	25.0	24.0	22.0	19.0	7" x 19" x 18 1/2"	**1683**

*AC INPUT 188-238 VAC STANDARD

OVERVOLTAGE PROTECTOR ACCESSORIES

ADJ. VOLT. RANGE VDC	MODEL	FOR USE WITH	PRICE
3-24	LH-OV-4	LK-340-A-FM, 341-A-FM	**$35**
3-47	LH-OV-5	LK-342-A-FM, 343-A-FM	**35**
3-70	LH-OV-6	LK-344-A-FM, 345-A-FM	**35**
3-70	Add "-OV" to	LK-350-FM to 352-FM	**100**
3-70	Model No	LK-360-FM to 362-FM	**135**

NOTES:

(1) Current rating applies over entire voltage range.

(2) Overvoltage protection up to 70 VDC as a built-in option for full-rack models. To order, add suffix "-OV" and add $100.00 to price of models LK-350-FM, 351-FM, 352-FM. For models LK-360-FM, 361-FM, 362-FM, add $135.00 and order by adding -OV to model number.

(3) Chassis slides for full rack models: add suffix "-CS" to model number and add $70.00 to the price, except for models LK-360-FM, LK-361-FM and LK-362-FM, for which add $120.00.

SPECIFICATIONS OF LK SERIES

DC output
voltage ranges shown in tables.

Regulated voltage

regulation line or load	0.015% or 1 mV whichever is greater for line variations from 105-132 VAC, (or 188-238 VAC LK-360-FM series); or for load changes from no load to full load.
remote programming resistance	200 ohms/volt
remote programming voltage	volt per volt
ripple and noise	500 uV RMS; with either pos. or neg. terminal grounded.
temperature coefficient	0.015%/°C

Constant current
(current regulated line and load)

Automatic crossover

voltage range	as shown in tables.
current range	minimum—5% of 40°C rating. maximum — as shown in tables.
regulation, line	less than 10 mA or 0.1% whichever is greater for Input Variations of 105-132 VAC (188-238 VAC LK-360-FM series).
regulation, load	less than 10 mA or 0.1% whichever is great — from 0 to rated VDC load voltage change.

AC input
105-132 VAC, 47-63 Hz. (188-238 Vac, 47-63 Hz LK-360-FM Series only). For operation at 50 Hz derate output current by 10%. 187-242 VAC, see AC option.

Ambient operating temperature range
continuous duty from 0°C to +71°C with load current ratings shown in tables.

Storage temperature range
-55°C to +85°C

Overload protection
Thermal

thermostat; automatic reset when over-temp. condition is removed.

Electrical

external overload protection: adjustable, automatic electronic current limiting circuit limits the output current to the preset value, thereby providing protection for load as well as power supply. Current limiting settability to 105% of rated current. internal failure protection: provided by fuse.

Input and output connections
terminal block on rear of chassis

Meters
voltmeter and ammeter on all models.

Controls
DC output controls

coarse and fine voltage adjust and coarse and fine current adjust on front panel.

Power

on-off switch, front panel, — ½ rack models; circuit breakers, front panel — full-rack models.

Remote Sensing
provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

Physical data

Series	Weight Lbs net	Weight Lbs ship	Size (Inches)
LK-340-AFM	35	41	5 3/16 x 8 3/8 x 16
LK-350-AFM	95	125	5 3/16 x 19 x 16 1/2
LK-360-AFM	135	170	7 x 19 x 18 1/2

Panel finish

brushed aluminum clear anodized panels with grey inlay (standard).

Accessories
rack adapters LRA-1, LRA-2 (LK-340 series only) chassis slides, over-voltage protectors, pot covers, blank panels. See catalog.

Options
AC input

Add suffix	for operation at:	Price Qty 1-14	Price Single Model Qty 15 & up	Price Mixed Model Qty 15 & up
For LK-340, LK-350 Series Only				
—V	187-242 VAC 47-63 Hz	12% or $30*	10%	12% or $30*
—V1	205-265 VAC 47-63 Hz	12% or $30*	10%	12% or $30
For LK-360 Series Only				
—V1	205-265 VAC 47-63 Hz	12% or $30*	10%	12% or $30*

*Whichever is greater

For 50 Hz operation derate current 10% for all models

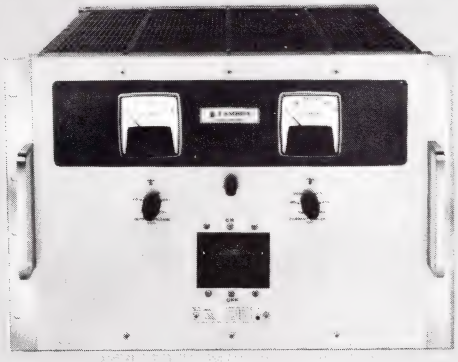
Fungus proofing

add suffix "R" to model number and add 10% to price.

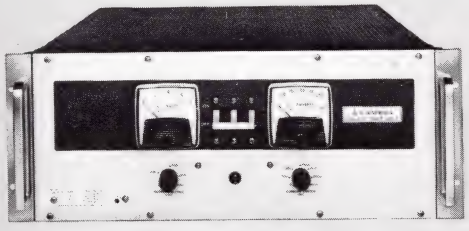
Guaranteed for 5 years
5-year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

LB SERIES
HIGH CURRENT, HIGH-EFFICIENCY POWER SUPPLIES

for use in main frame computers, component life tests aging racks and test equipment



LB-720 Series High-Efficiency Power Supplies



LB-700 Series High-Efficiency Power Supplies

Convection-cooled — no internal fans

0-7.5 VOLTS

MODEL	MAX AMPS AT AMBIENT OF: (1) 40°C	50°C	60°C	71°C	DIMENSIONS	PRICE
LB-701-FM-OV	300	270	235	200	7" x 19" x 20 1/16"	$2728
LB-721-FM-OV	500	450	400	350	12 3/16" x 19" x 22 1/16"	4333

0-15 VOLTS

LB-702-FM-OV	180	170	160	150	7" x 19" x 20 1/16"	$2728
LB-722-FM-OV	300	265	225	180	12 3/16" x 19" x 22 1/16"	4333

0-36 VOLTS

LB-703-FM-OV	80	75	70	65	7" x 19" x 20 1/16"	$2728
LB-723-FM-OV	135	130	125	120	12 3/16" x 19" x 22 1/16"	4333

0-60 VOLTS

LB-704-FM-OV	50	47	44	40	7" x 19" x 20 1/16"	$2728
LB-724-FM-OV	80	75	70	65	12 3/16" x 19" x 22 1/16"	4333

0-120 VOLTS

LB-705-FM	25	22	19	16	7" x 19" x 20 1/16"	$2568
LB-725-FM	40	36	32	28	12 3/16" x 19" x 22 1/16"	4173

0-300 VOLTS

LB-706-FM	10	9.5	9.0	8.0	7" x 19" x 20 1/16"	$2568
LB-726-FM	16	15	14	13	12 3/16" x 19" x 22 1/16"	4173

NOTES:

(1) Current rating applies over entire voltage range.
(2) Prices include meters. LB Series models are not available without meters. Prices for all models up to and including 60 VDC include built-in over-voltage protection.
(3) Chassis slides are available with LB-701 thru LB-706-FM models only. Add suffix "CS" to the model number and add $250.00 to the prices.

Outstanding Features

Up to 87% efficiency

Regulation

line 0.05% + 6 mV
load 0.1% + 10 mV

Ripple

10 mV RMS max. by use of electronic ripple reducer

Convection-cooled

no blowers or internal fans, no external heat sinking

Overvoltage protection

standard on all models up to 60 VDC rating

No overshoot

on turn-on, turn-off or power failure

Remotely programmable

Remotely sensing

Magnetics

designed to MIL-T-27C, grade 6

Completely protected

short circuit proof — continuously adjustable automatic current limiting

Constant I /Constant V

by automatic crossover

Series operation

Multi-current-rated

for 40°C, 50°C, 60°C, 71°C

SPECIFICATIONS OF LB SERIES

DC output
voltage ranges as shown in tables

Constant voltage

regulation, line	0.05% + 6 mV for line variations from 187-229 VAC or from 229-187 VAC
regulation, load	0.1% + 10 mV for load variations from 0 to full load
remote programming, resistance	200 ohms/volt nominal
remote programming, voltage	volt per volt
ripple and noise	10 mV RMS max; 100 mV RMS max for LB-706-FM; 150 mV RMS max for LB-726-FM. With "V" option: 15 mV RMS for LB-701 thru LB-705; 150 mV RMS for LB-706
temperature coefficient	(0.03% + 0.5 mV/)°C

Constant current
(current regulated line and load)

Automatic crossover current range	zero to max. current as shown in tables
regulation (line and load combined)	less than 1% + 10 mA for 721-725; less than 1% for 701-706 (1% + 50 mA for LB-726-FM) for input variations from 187-229 VAC or from 229-187 VAC and from 0 to 95% output voltage change
ripple and noise	for LB-701-LB-705-FM and LB-721-FM-OV-LB-725-FM less-than (1/Vout*)% RMS of load current either positive or negative terminal grounded for LB-706-FM, less than (10/Vout*)% of load current for LB-726-FM, less than (15/Vout*)% of load current. With "V" option (1.5/Vout*)% of I DC for LB-701-705; (15/Vout)% of I dc for LB-706

*Vout equals I out R_L measured at output terminals of power supplies.

AC input
208 ± 10% VAC; 57-63 Hz, 3 phase ± 10% max. phase unbalance, 4 wire. For operation at other than 57-63 Hz, see AC input option.

Efficiency
up to 87% efficiency.

Response time
for a 20% load change between 20% and 100% load, the voltage will recover to within 0.5 volt in 150 milliseconds.

Ambient operating temperature range
continuous duty from 0° to 71°C with load current rating shown in tables.

Storage temperature
-55° to +85°C.

Overload protection
Thermal
thermostat required resetting of circuit breaker to re-energize.

Electrical
external overload protection: adjustable, automatic electronic current limiting circuit limits the output current to the preset value, thereby providing protection for load as well as power supply. Current limiting settability to 110% of rated current.
internal failure protection: provided by primary circuit breaker.

Overvoltage protection
built-in overvoltage protection on all models up to 60 VDC ratings.

Input connections
terminal block on rear of chassis.

Output connections
LB-700 series: 2 heavy duty studs 1/2"-20 on LB-701-FM-OV and LB-702-FM-OV models; all other models: 5/16"-24 studs on rear of chassis. LB-720 series: 4 heavy duty studs 5/16"-24 on LB-721-FM-OV and LB-722-FM-OV models; all other models: 2 studs, 5/16"-24.

Meters
independent voltmeter and ammeter with ±2% accuracy.

Controls
DC output and control
coarse and fine voltage adjust and coarse and fine current adjust on front panel.

Power
circuit breaker to protect against internal failure and to provide an on-off control on front panel. Pilot lamp on front panel energizes when circuit breaker is "on"

Remote sensing
provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation up to 5 Volts in each leg..

Physical data

Series	Weight Lbs net	Weight Lbs ship	Size (Inches)
LB 700	230	240	7 x 19 x 20 1/16
LB 720	360	410	12 3/16 x 19 x 22 1/16

Panel finish
brushed aluminum clear anodized panels with grey inlay.
Chassis finish
grey, FED. STD. 595 No. 26081

Options

AC input
For LB 700 Series Only

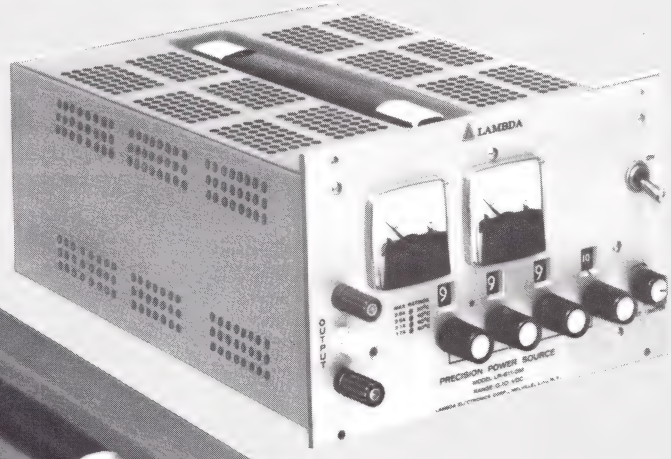
Add suffix	for operation at:	Price Qty 1-14	Price Single Model Qty 15 & up	Price Mixed Model Qty 15 & up
–V	208 ± 10% VAC 47-53 Hz 3 phase	12%	10%	12%
For 50 Hz operation derate current 10%.				
–V1	230 ± 10% VAC 57-63 Hz 3 phase	12%	10%	12%
For LB-720 Series Only				
–V1	230 ± 10% VAC 57-63 Hz 3 Phase	12%	10%	12%

Accessories
chassis slides (LB-701-FM-OV thru LB-706-FM models only) and pot covers. See catalog.

Guaranteed for 5 years
5-year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

LR SERIES
HIGH PERFORMANCE
POWER SUPPLIES

for automatic test equipment in systems where high accuracy is required.



LR-613-DM ½ Rack Model
with DIGITAL READOUT



LR-602A-FM ¼ Rack Model

MODELS	MAX. CURRENT AMPS AT AMBIENT OF: (1) 30°C	40°C	50°C	60°C	DIMENSIONS	PRICE
0-20 VOLTS						
LR-602A-FM	1.1	0.95	0.80	0.64	5 3/16" x 4 3/16" x 15 1/4"	**$589**
0-40 VOLTS						
LR-613-DM*	1.0	0.9	0.75	0.6	5 3/16" x 8 3/8" x 10 3/32"	**$1059**

*Provided with digital readout.

NOTES:

(1) Current rating applies over entire voltage range. Ratings based on 55-65 Hz operation. Derate current 10% for 50 Hz input.

Outstanding Features

Regulation
0.0005% + 100 uV line or load

Ripple
35 uV RMS

Accuracy
0.01% + 1 mV

Stability
0.001% + 100 uV over 8 hr. period

Temperature coefficient
(0.001% + 10 uV)/°C

Constant I/Constant V
by automatic crossover

2 meters
monitor both voltage and current simultaneously and continuously.

Digital readout
for voltage output on all LR-DM models.

Convection-cooled
for convenience and reliability . . . no blowers or external heat sinks

Remote sensing

Remote programming
by external voltage or resistance for convenience in systems, test equipment and automatic equipment applications.

Auto series/auto parallel
with Master-Slave tracking

Completely protected
short-circuit proof; continuously adjustable automatic current limiting.

Overvoltage protection
available as low cost add-on accessory.

SPECIFICATIONS OF LR SERIES

DC output
voltage ranges shown in tables.

Regulated Voltage
regulation, line . . . . . .0.0005% plus 100uV for line variations from 105-132 VAC.
regulation, load. . . . . .0.0005% plus 100uV for load variations from 0 to full load.

remote programming resistance . . . . . .1000 ohms/volt. nominal
remote programming voltage . . . . . .volt per volt
ripple and noise. . . . . .35uV RMS, 100uV pk-pk with either positive or negative terminal grounded, with 60 Hz input.
temperature coefficient . . . . . .(0.001% plus 10uV)/°C

Constant current
(current regulated line or load)

Automatic crossover

voltage range . . . . . .as shown in tables.
current range . . . . . .continuously adjustable from 1% to 100% of 30°C rating.
regulation (line or load) . . . . . .less than 2.0mA for input variations of 105-132 VAC and from 0 to rated VDC load voltage change.

ripple and noise . . . . . .less than 500uA with either pos. or neg. terminal grounded.

AC input
105-132 VAC, 47-440 Hz (derate DC output current 10% at 50 Hz). 187-242 VAC or 205-265 VAC, 47-440 Hz, see AC input option.

Accuracy *
0.01% plus 1 mV at 25°C.

Stability *
0.001% plus 100 uV over any 8-hour period after 30 minute warmup.

*Remote programming mode only on FM models.

Ambient operating temperature range
continuous duty from 0° to +60°C with load current ratings shown in table

Storage temperature range
–55°C to + 85°C.

Overload protection
Thermal

thermostat; automatic reset when overtemperature condition is removed.

Electrical

limiting circuit limits the output current to the preset value, thereby providing protection for load as well as power supply. Current limiting settability to 105% of rated current.

internal failure protection: provided by fuse.

Input and output connections
covered DC output and AC input terminal blocks on rear of chassis.

Controls
DC output controls

coarse and fine voltage adjust on FM models; 5 digits voltage readout system including a continuous vernier on DM models.

Current limiter

coarse and fine front panel concentric controls on FM models; single front panel control on DM models.

Power

on-off switch, front panel.

Remote sensing
provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation, rear panel.

Physical data

Series	Weight Lbs net	Weight Lbs ship	Size (Inches)
LR-602A-FM	11	14	5 3/16 x 4 3/16 x 15 1/4
LR-613-DM	14	17	5 3/16 x 8 3/8 x 10 3/32

Retractable Bench Rest included for LR-FM Series

Finish

DM Models only . . . . . .Brushed aluminum clear anodized panels (standard).
FM Models only . . . . . .Tan glass-filled, flame-retardant nylon panels.

Accessories
rack adapters LRA-1, LRA-2, overvoltage protectors, pot covers, blank panels. See page 153.

Options
AC input

Add suffix	for operation at-	Price Qty 1-14	Price Single Model Qty 15 & up	Price Mixed Model Qty 15 & up
–V	187-242 VAC 47-440 Hz	12% or $30*	10%	12% or $30*
–V1	205-265 VAC 47-440 Hz	12% or $30*	10%	12% or $30*

*Whichever is greater
For 50 Hz operation derate current 10%.

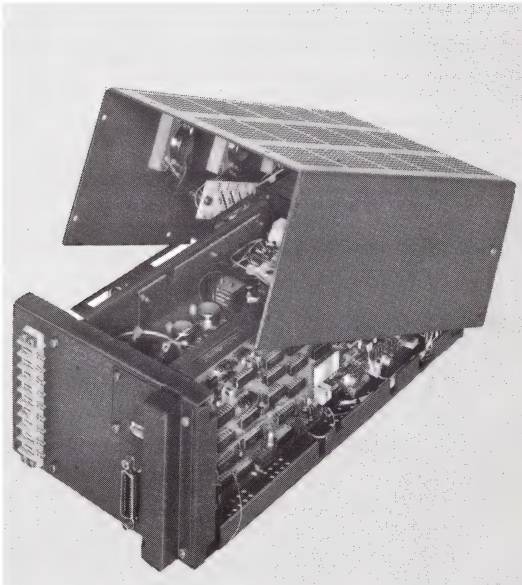
Fungus proofing

add suffix "R" to model number and add 10% to price except LR-DM models, for which fungus proofing option doesn't apply.

Guaranteed for 5 years
5-year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end-of-5 years.

LF-9-04 POWER SUPPLY
LF-9-04-GPIB POWER SUPPLY

The most advanced automatic test equipment power supplies on the market today



Now Lambda offers two power supplies for your automatic test equipment power supply requirement. It provides plus or minus 0-50 volts at 2 amperes DC with the following features:

Features

LF-9-04

- 8, 12, or 24 bit BCD programming or ASCII programming
- 0.01% regulation, line or load
- A 2 msec programming time for full voltage compliance
- 15 mV accuracy for 50 V BCD programming
  30 mV accuracy for 50V of ASCII programming
- Resolution 50 mV (BCD) at 50 V; 100 mV for ASCII
- 100% sinking capability
- ripple—10mV pk-pk (BCD) on 50 Volt range; 20 mV for ASCII
- optical isolation
- current limit flag
- busy ready flag
- Current limit programming
- current over-ride
- zero over-ride
- inverted/ noninverted input
- zero adjust
- worst-case overshoot—1 volt
- transient response—1.2 msec
- unique digital circuitry designed with CMOS

LF-9-04-GPIB

- IEEE Standard 488-75 interconnector bus ASCII programming
- 0.01% regulation, line or load
- A 2 msec programming time for full voltage compliance
- 30 mV accuracy for 50V of ASCII programming
- Resolution 100 mV at 50 V
- 100% sinking capability
- ripple—20 mV pk-pk on 50 Volt range
- optical isolation
- Current limit programming
- zero adjust
- worst-case overshoot—1 volt
- transient response—1.2 msec
- unique digital circuitry designed with CMOS

Ordering Information

Model	Price	Model	Price
LF-9-04	$1070	LF-9-04-GPIB	$1284

SPECIFICATIONS OF LF-9-04

DC output

Volt (VDC)	MAX AMPS AT AMBIENT OF: 40°C	50°C	60°C
0 to ± 49.95	1.98	1.8	1.6

Output range

X1 range: ± 9.99V in 10 mV steps
*X5 range: ±49.95V in 50 mV steps
X10 range: ASCII only – selected automatically (0- to ±49.9 V in 100 mV steps

Source or sink

1.98 amps continuous

Regulated voltage

regulation line ..... 0.01% – for line variations 105-132VAC (see AC input option)
regulation load (all ranges) ..... 0.01% – for load variation of 0 to full load.
ripple and noise ..... X1 range: 2.0 mV pk-pk max
*X5 range: 10 mV pk-pk max
X10 (ASCII): 20 mV pk-pk max
temperature coefficient ..... Voltage
X1 range: .005%/°C+35 μV/°C
*X5 range: .005%/°C + 0.115 mV/°C
X10 range: (ASCII only) .005%/°C + .215 mV/°C
Current
All ranges: 500 μA/°C

Constant current operation

Current Range: 1% to 99% of full scale
Regulation line . . . . . 1 mA max
load . . . . . 20 mA max

AC input

105-132VAC, 47-440Hz. For 187-242 or 205-265 VAC see AC input option.

Ambient operating temperature range

continuous duty from 0° to 60°C with load current ratings shown in table.

Storage temperature range

–55°C to +85°C

Basic accuracy

(at 25°C, 115VAC input and no load) ..... Voltage
X1 range: 3 mV
*X5 range: 15 mV
X10 range: 30 mV (ASCII only)
Current
All ranges: 10 mA

Resolution ..... Voltage

X1 range: 10 mV
*X5 range: 50 mV
X10 range: 100 mV (ASCII)
Current
All ranges: 20 mA

Transient response

1.2 msec to within .05% of full scale for 90% load change
*BCD only

Overshoot

Worst case overshoot 1 volt under any conditions

Input data word:

A 24 Bit data word is used comprising of 12 bits BCD voltage programming, 8 bits BCD current and one bit each for gain, polarity and current limit override. Data word may be accepted in 3, 2, or 1 sequential segments of 8, 12, 24 bits, or ASCII to make up the 24 bits. Current is programmed as a percentage of full scale.

Programming time:

see graphs on page 113.

Data validity

10 μsec

Data loading

Logic Levels–all 0 to +5V. One CMOS load per line.
Compatible with TTL or DTL
Interface requirements:
CMOS – direct
DTL – direct
TTL – direct, with a 10K pull up resistor on each data line to +5V bus.

Control lines

One TTL or DTL buffer per line
Data Flag – CMOS input
Zero Override – requires sinking of 15mA, compatible with DTL or TTL buffers
Final Transfer Pulse – CMOS input

Output flags

1. Current Limit Flag – optical coupler, conducting when in current limit.
2. Busy Ready Flag – open collector, logic zero when ready to accept new data.

Cooling

Convection-cooled, no heatsinks or blower necessary

Mounting positions

one mounting position on horizontal plane
Input/output connections through heavy duty barrier strip and connector

Physical data

Model (Package 9)	Size (inches)	Weight lbs net	lbs ship
LF-9-04	4 15/16 x 7 1/2 x 14	20	22

Options

AC input

Add Suffix	for operation at:	Add to Price
–V	187-242 VAC, 47-440 Hz	12%
$-V_1$	205-265 VAC, 47-440 Hz	12%

Accessories:

rack adapters LRA-15, LRA-17. Overvoltage protectors, chassis slides, blank panels. See catalog.

Guaranteed for 5 years.

5-year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

SPECIFICATIONS OF LF-9-04-GPIB

DC output

Volt (VDC)	MAX AMPS AT AMBIENT OF: 40°C	50°C	60°C
0 to ± 49.95	1.98	1.8	1.6

Output range

X1 range: ± 9.99V in 10 mV steps
X10 range: selected automatically (0- to ±49.9 V in 100 mV steps

Source or sink

1.98 amps continuous

Regulated voltage

regulation line ..... 0.01% – for line variations 105-132VAC (see AC input option)
regulation load (all ranges) ..... 0.01% – for load variation of 0 to full load.
ripple and noise ..... X1 range: 2.0 mV pk-pk max
X10 : 20 mV pk-pk max
temperature coefficient ..... Voltage
X1 range: .005%/°C+35 μV/°C
X10 range: .005%/°C + .215 mV/°C
Current
All ranges: 500 μA/°C

Constant current operation

Current Range: 1% to 99% of full scale
Regulation line . . . . . 1 mA max
load . . . . . 20 mA max

AC input

105-132VAC, 47-440Hz. For 187-242 or 205-265 VAC see AC input option.

Ambient operating temperature range

continuous duty from 0° to 60°C with load current ratings shown in table.

Storage temperature range

–55°C to +85°C

Basic accuracy

(at 25°C, 115VAC input and no load) ..... Voltage
X1 range: 3 mV
X10 range: 30 mV
Current
All ranges: 10 mA

Resolution ..... Voltage

X1 range: 10 mV
X10 range: 100 mV
Current
All ranges: 20 mA

Transient response

1.2 msec to within .05% of full scale for 90% load change

Overshoot

Worst case overshoot 1 volt under any conditions

Input Data Format:

Data is entered in bit-parallel, byte-serial format as specified by IEEE Std. #488. The 24 programming bits contain 12 bits BCD voltage programming, 8 bits BCD current programming and one bit each for gain, polarity and mode. The valid data format is ASCII.

Programming time:

see graphs on page 113.

Data Loading:

Logic levels ("O" ⩾ + 2.0V; "1" ⩽ + 0.8V) and interface requirements are as specified in IEEE Std. #488.

Data Input Lines:

DIO-1 thru 8 as specified in IEEE Std. #488.

Control Lines:

ATN, EOI, IFC, NRFD, NDAC, DAV, SRQ, REN* as specified in IEEE Std. #488. All control and data input lines are accessed through 24-pin GPIB connector on back panel. The SRQ line is activated by a current overload condition while in constant voltage mode or overvoltage limit condition while in constant current mode. Mode of operation programmed with mode bit.

*REN is not a usable function for the LF-GPIB and is terminated in a logical "O".

Cooling

Convection-cooled, no heatsinks or blower necessary

Mounting positions

one mounting position on horizontal plane
Input/output connections through heavy duty barrier strip and connector

Physical data

Model (Package 9)	Size (inches)	Weight lbs net	lbs ship
LF-9-04-GPIB	4 15/16 x 7 1/2 x 14 5/8	20	22

Options

AC input

Add Suffix	for operation at:	Add to Price
–V	187-242 VAC, 47-440 Hz	12%
$-V_1$	205-265 VAC, 47-440 Hz	12%

Accessories:

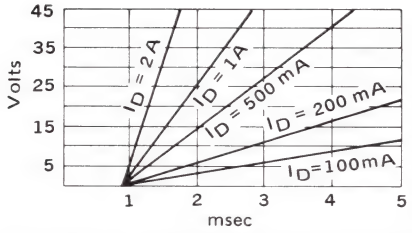
rack adapters LRA-15, LRA-17 Overvoltage protectors, chassis slides, blank panels. See catalog.

Guaranteed for 5 years.

5 year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

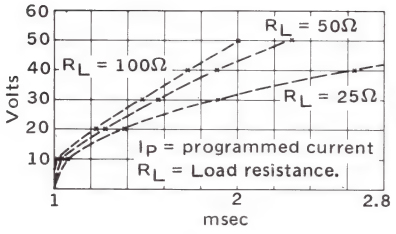
SPECIFICATIONS OF LF-9-04, LF-9-04-GPIB

Programming Time mSec Vs Programmed Voltage Step (Constant Current Load)

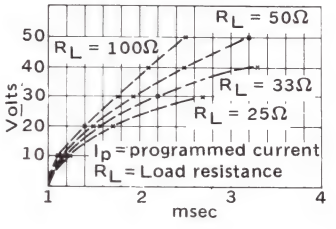


I_D = DIFFERENCE BETWEEN PROGRAMMED CURRENT AND LOAD CURRENT APPLIES TO CONSTANT CURRENT NON-CAPACITIVE LOAD

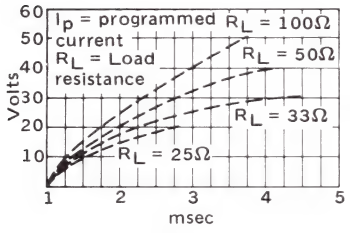
Programming Time mSec Vs Programmed Voltage Step (Resistive Load)



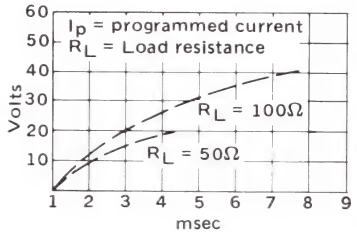
Ip = 2.0A
100% Full Load



Ip = 1.5A
75% Full Load

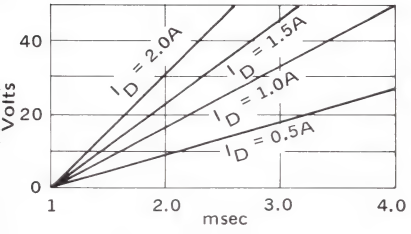


Ip = 1.0A
50% Full Load

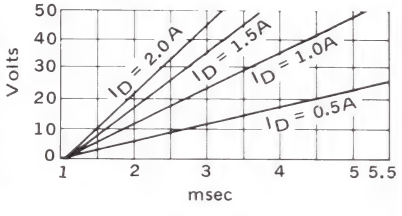


Ip = 0.5A
25% Full Load

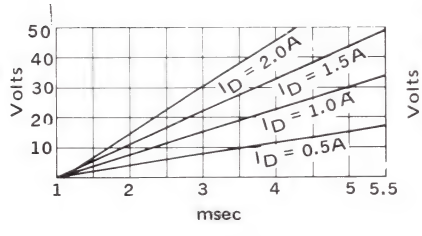
Programming Time mSec Vs Programmed Voltage Step (Capacitive Load)



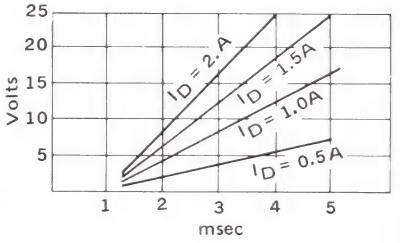
C_L = 25 mfd
Load Capacitance



C_L = 50 mfd
Load Capacitance



C_L = 100 mfd
Load Capacitance



C_L = 200 mfd
Load Capacitance

I_D = Difference between programmed current and constant load current.

DEFINITION OF TERMS:

Resolution:
Minimum programmable change

Basic Accuracy:
Maximum deviation from programmed value at 25° constant temperature, 115 VAC and no load.

Programming Time:
Time, after data entry, required for the supply to sett within 0.05% full scale.

Data Flag: (Not Applicable to GPIB)
Customer generated 3.3 μsec minimum pulse, beginni at least 2 μsec after date is presented, to signal that da is available and ready for processing.

Final Transfer Pulse: (Not Applicable to GPIB)
Customer generated 2 μsec minimum pulse beginni at least 300 μsec after first data flag, to transfer da from input shift register into storage and the DAC This pulse is internally generated by the system f ASCII.

Data Validity: (Not Applicable to GPIB)
Minimum time for which data must remain present afte data flag.

Transient Response:
Time required for supply to return to within 0.05% fu scale of programmed value, for 90% change of load.

Overshoot:
Magnitude of voltage by which output may excee programmed value or fall below zero volts durin turn-on, turn-off, voltage to current limit crossover c current limit to voltage crossover and programming.

Zero Override: (Not Applicable to GPIB)
Input signal pulse programs output of power supply t zero volts. This signal is also activated when input dat plug is pulled out. Zero override is a system featur that may be utilized in an emergency by forcing th output to zero volts from any previous state. When i that mode the output will be kept at zero ±50 mV max While the output ripple will be limited to 15 mV pk-p max.

Output Flags:
System generated signal, available to the user throug the input data connector.

SUMMARY OF THE IEEE STD. #488

See Specifications of LF-9-04-GPIB

IEEE Standard #488 specifies a system for the interconnection of as many as 14 pieces of test equipment on a single 24-wire bus controlled by a central processing unit. The bus consists of 8 bidirectional data lines, 8 command lines and 8 ground lines. Data is transferred along the bus via a specific 3-wire "handshake" process. This process greatly reduces the possibility of lost data since any one operation must be confirmed by all addressed units before the following operation may commence.

The address system allows the controller to identify the units which are to transmit or receive data while allowing the other units on the bus to function uninterrupted. The service request (SRQ) line provides each module on the bus with the ability to inform the controller if a particular condition in that module warrants attention or service.

Listed below are the designations of the 8 command lines and a brief function description for each:

1. **ATN (ATTENTION)** — This line is used to call the attention of all units on the bus (i.e., all units are listening). All command instructions must be given under this signal.
2. **IFC (INTERFACE CLEAR)** - This line is used to set the interface—parts of which are contained in all units on the bus—at a known quiescent state.
3. **SRO (SERVICE REQUEST)** - This line provides a means for each unit on the bus to indicate to the controller that a condition exists which may require attention or service.
4. **EOI (END OR IDENTIFY)** - This line is used to indicate the end of a particular multiple-byte transfer sequence.
5. **REN (REMOTE ENABLE)** - This line is used to select between two alternate sources of device programming data (i.e., computer control or local control).

The remaining three commands comprise the three-wire "handshake" process. This process utilizes interlocking command sequences to transfer each data byte across the interface. These sequences can only proceed at the rate of the slowest addressed unit on the bus, thus assuring that all units on the bus can completely assimilate the data.

6. **DAV (DATA VALID)** - This command is used by the "talker" to indicate that the data on the DIO signal lines is valid and ready to be processed.
7. **NRFD (NOT READY FOR DATA)** - This line is used by the "listeners" on the bus to indicate whether or not they are ready to process the next byte of data.
8. **NDAC (NOT DATA ACCEPTED)** - This line is used by the "listeners" on the bus to indicate that the data on the line has been processed and can now be removed.

Consult Factory For:

A. Application information using BCD as input format.

B. Application information using IFC as an emergency shutdown.

ACCESSORIES

Overvoltage Protectors Accessories

	Adj. Volt. Range VDC	Model	For Use With	Price
	3-24	**LH-OV-4**	LP-530-FM, LP-531-FM, LK-340A-FM, LK-341A-FM, LP-410A-FM. LP-411A-FM, LPD-421A-FM, LR-602A-FM LP-520-FM, LP-521-FM	**$ 35**
	3-47	**LH-OV-5**	LP-532-FM, LK-342A-FM, LK-343A-FM, LP-412A-FM, LPD-422A-FM, LP-522-FM	**35**
	3-70	**LH-OV-6**	LP-533-FM, LK-344A-FM, LK-345A-FM, LP-413A-FM, LPD-423A-FM, LP-523-FM, LP-413A-FM, LR-613-DM	**35**
		Add "-OV" to power supply model number	LK-350-FM, LK-351-FM, LK-352-FM,	**100**
			LK-360-FM, LK-361-FM, LK-362-FM	**135**

Adjustable Crowbar type (Mounting provisions provided 2 terminal connections.)

RACK ADAPTERS



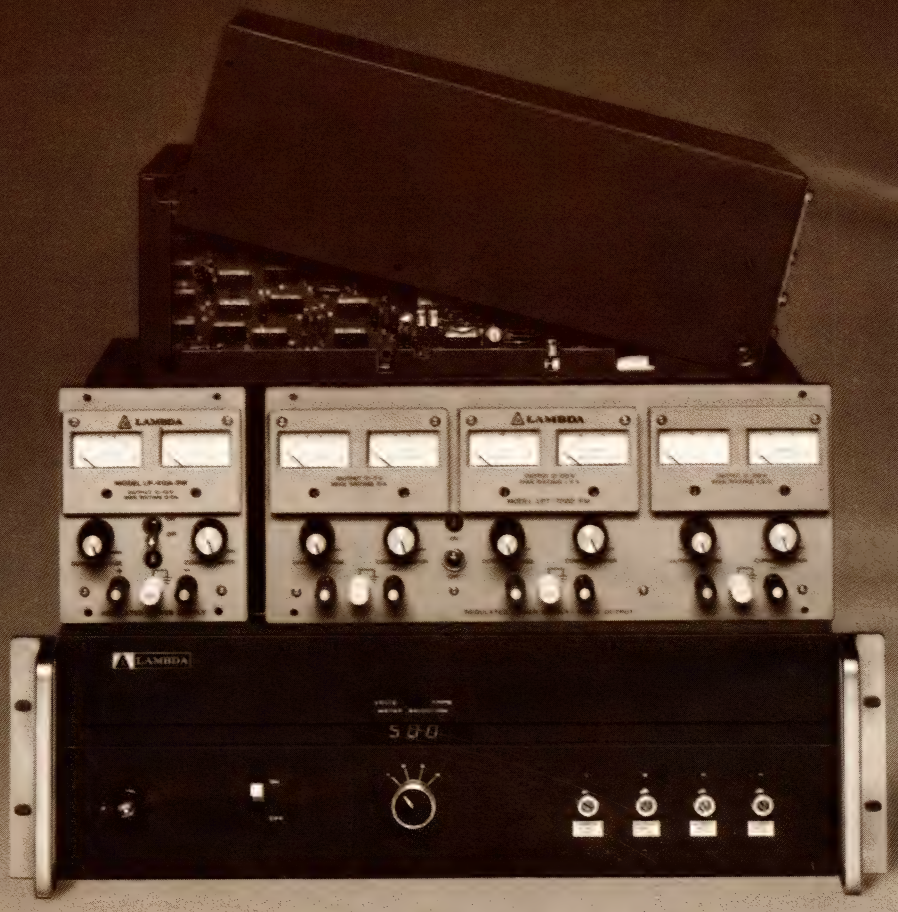
LRA-1 Rack Adapter
5 3/16"H x 19"W x 16 1/2"D
For use with LP, LPD, LK, LR, series **$85**



LRA-2 Rack Adapter
5 3/16" Heights
For use with LP, LPD, LK LR series **$50**

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Circuit detects 2's-complement overflow

Thinh Van Nguyen
Technology Service Corp, Los Angeles, CA

The addition of two 2's-complement numbers ignores the resulting carry. A sum always has its sign bit at the most significant position; however, if the sum exceeds the range represented by the same number of bits, overflow results. This detector circuit recognizes overflow conditions and forces the sum to its maximum value (either positive or negative) by examining the sign bits of the summed numbers:

- If two numbers have different signs, their sum is always within range; no correction is needed.
- If two numbers have the same sign, overflow occurs when the sum of two negative numbers is positive or when the sum of two positive numbers is negative.

The **figure** shows the 8-bit detector circuit, which, as described, examines the sign bits of two numbers in conjunction with the sign bit of their sum. The circuit switches data to maximum positive or maximum negative, or lets the result through, as shown in the **table**.

EDN

(a)

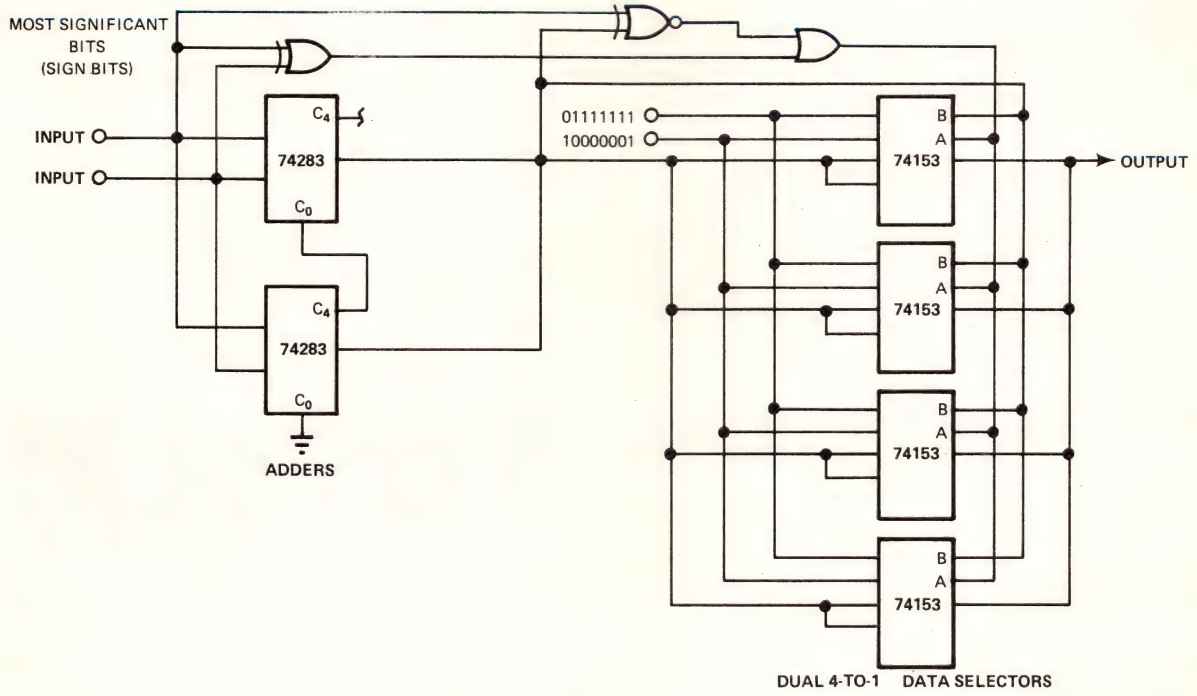
SIGNS OF NUMBERS	SIGN OF SUM	CONDITION	REPRESENTED AS
0 0	1	OUT OF RANGE	01111111 (MAX POS)
1 1	0	OUT OF RANGE	10000001 (MAX NEG)
0 0	0	WITHIN RANGE	LET RESULT GO THROUGH
1 1	1		
0 1	DON'T CARE		
1 0	DON'T CARE		

(b)

A	B	OUTPUT
1	DON'T CARE	LET THROUGH
0	0	10000001
0	1	01111111

The signs of the two numbers, *in conjunction with the sign of their sum* ***(a)****, cause the output* ***(b)*** *to switch to the appropriate value.*

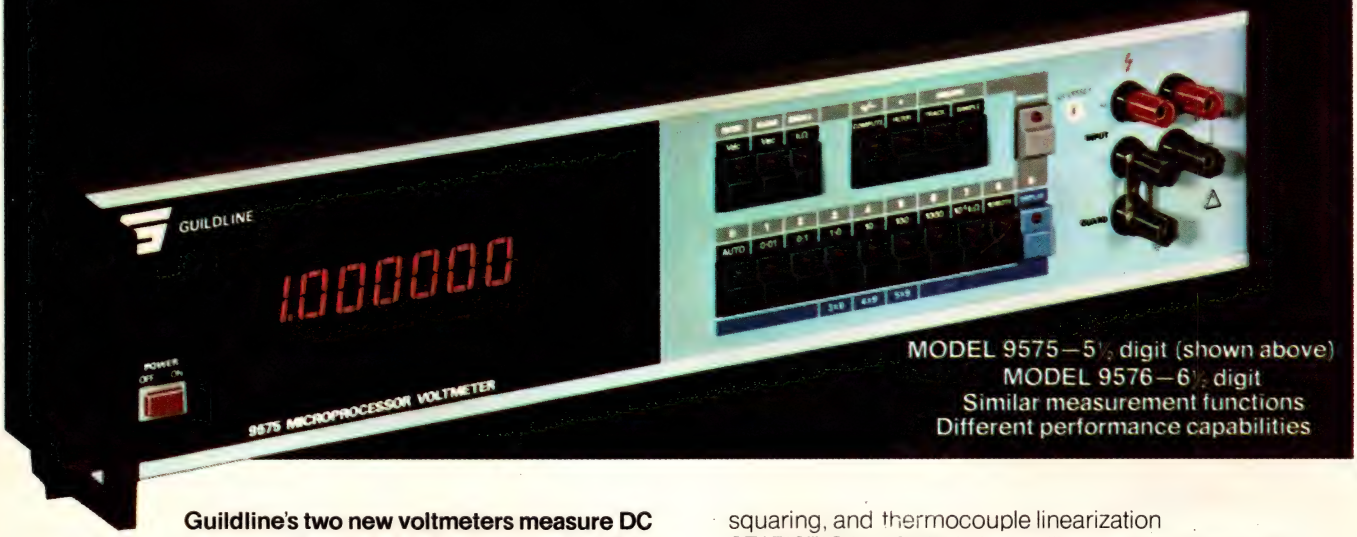
To Vote For This Design, Circle No 450



An 8-bit detector circuit *senses an overflow condition and forces the sum to its maximum value.*

IMPROVED PERFORMANCE

The "INTELLIGENT" DVM's from Guildline



MODEL 9575—5½ digit (shown above)
MODEL 9576—6½ digit
Similar measurement functions
Different performance capabilities

Guildline's two new voltmeters measure DC voltage, AC voltage and resistance PLUS they use their measured results as a data base for processing information on a real time basis.

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PLUS

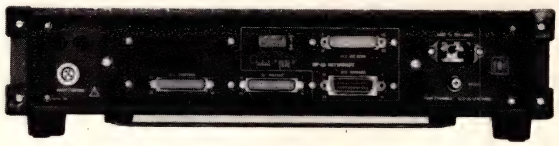
Microprocessor Controlled Features include automatic calibration balance, 9 built-in programs—21 individual calculations.
Full math capabilities: $Y = Ax + B$ or $Y = A(x + B)$

PLUS

Special Processing Power
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CONTROL—high-low limits, real time programmable clock, full internal time control: start, stop, interval between measurements and run time

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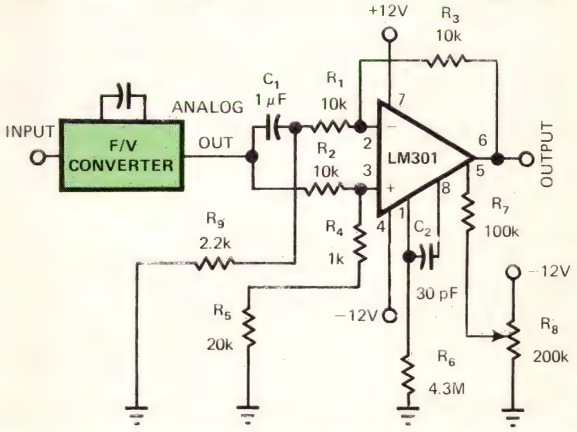
For more information, Circle No 67

Remove F/V-converter ripple

Wesley Grenlund
Beloit Corp, Rockton, IL

A frequency-to-voltage converter transforms a digital pulse train into a corresponding analog signal. Because of the nature of the conversion technique, an ac ripple remains superimposed on the dc signal—some applications can't live with this ripple. To eliminate it, you might increase the size of the integration capacitor, but that approach reduces the converter's speed. The circuit diagrammed in the figure, however, reduces ripple by 40 dB and still retains its response speed.

The circuit ac-couples the inverting input of an operational amplifier and direct-couples the noninverting input; the op amp's common-mode rejection ratio cancels the ac component in the output. The degree of cancellation depends on the matching of the input and feedback circuits. R_5 provides adjustment for variations in amplifier parameters; vary it for minimum ac feedthrough at the lowest frequency of interest, and adjust R_8 for minimum dc offset.



Take advantage *of an op amp's common-mode rejection ratio to provide up to a 40-dB reduction in the ripple of the output of an F/V converter.*

EDN

To Vote For This Design, Circle No 451

Improve current-source performance

Carl Nelson
National Semiconductor, Santa Clara, CA

Current sources consisting of an op amp and a unity-gain transfer device serve well in applications requiring fixed or programmable output current. **Fig 1** illustrates the use of a bipolar transistor as a transfer device in such a source; unfortunately, the transistor's less-than-unity transfer ratio—its error equals $1/(1+h_{FE})$—limits this circuit's initial accuracy and output impedance. At voltages approaching the transistor's saturation voltage, h_{FE} falls off rapidly, introducing a large error.

The addition of a few resistors, as shown in **Fig 2,** dramatically improves performance; the circuit tracks well with a collector-emitter voltage lower than Q_1's saturation voltage. This modification senses Q_1's base current through R_1 and includes this voltage in the control amplifier's feedback loop. Because the controlled parameter then equals the collector current, the output remains independent of h_{FE}. You must, however, maintain this identity:

$$R_5/R_6 = R_3/R_2 = R_4/R_1.$$

Output current equals V_{IN}/R_1, assuming zero offset voltage and input current for IC_1. Input impedance is given by

$$Z_{IN} = -(R_5 R_1 h_{FE}/R_4).$$

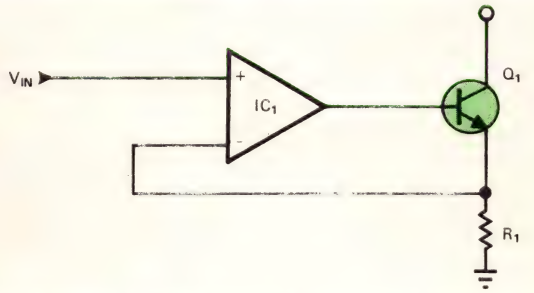


Fig 1—A simple circuit *provides a satisfactory current source.*

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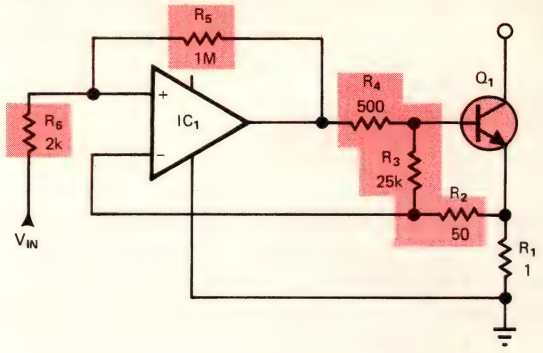
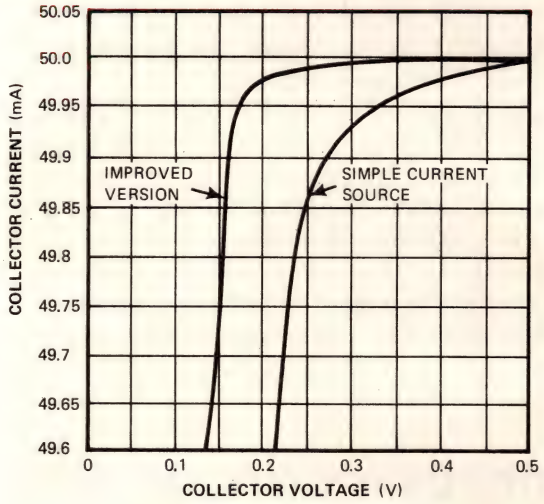


Fig 2—You can improve the performance *of the current source by adding a few resistors.*



PARAMETER	OLD	NEW
OUTPUT RESISTANCE	330k	10 M
REGULATION $0.5V \leq V_{OUT} \leq 50V$	0.3%	0.01%

Fig 3—Compare the performance *of the basic circuit and the improved version.*

The values shown in **Fig 2** are typical for a 50-mA output current. **Fig 3** compares the performance of the circuits shown in **Figs 1** and **2**. **EDN**

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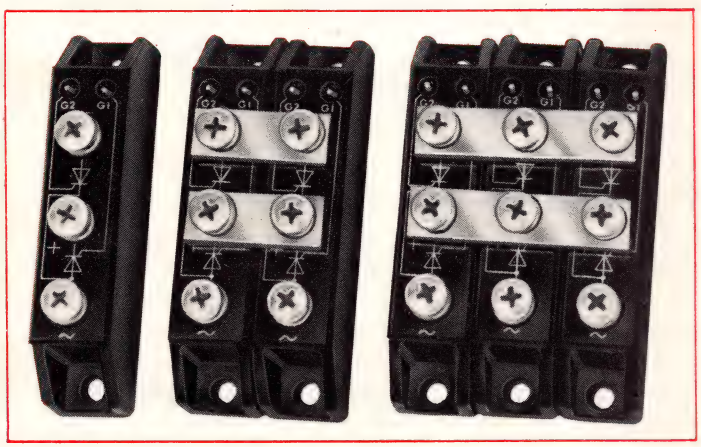
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If it's power you need, we have the product and range

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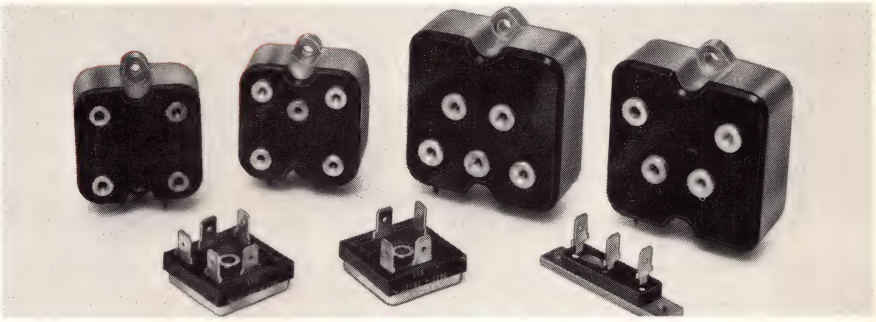


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For more information, Circle No 68

High-speed (1-GHz) scope mainframe resolves 20 psec on full-size screen

High-speed electron-optics technology and microwave-circuit techniques combine in this oscilloscope to double the state-of-the-art bandwidth from 500 MHz to 1 GHz.

Model 7104 integrates a distributed horizontal-deflection system, a meshless scan-expansion lens and a microchannel-plate electron multiplier with microstripline elements. The combination permits observation of events as short as 20 psec in duration, using calibrated sweep speeds of 200 psec/div. You can see these very high-speed single-event pulses directly, without resorting to photography, because display brightness has been increased three orders of magnitude compared with previously available high-speed CRTs.



Proprietary developments in CRT technology *allow Model 7104 to achieve its photographic writing speed of 20 cm/nsec. Measuring 23.5×12×13.6 in., the high-speed scope mainframe weighs 44 lbs and accepts four 7000 Series plug ins, including three specifically developed to support it.*

To obtain the 7104's gigahertz performance, engineers at Tektronix also developed proprietary very high-speed ICs, then improved on existing packaging techniques by designing metallized-elastomer interconnects to lower reflection losses and mismatches (EDN, January 5, 1978, pgs 36-42). And to ensure maximum usefulness in a laboratory environment, they incorporated into the mainframe a number of significant features:

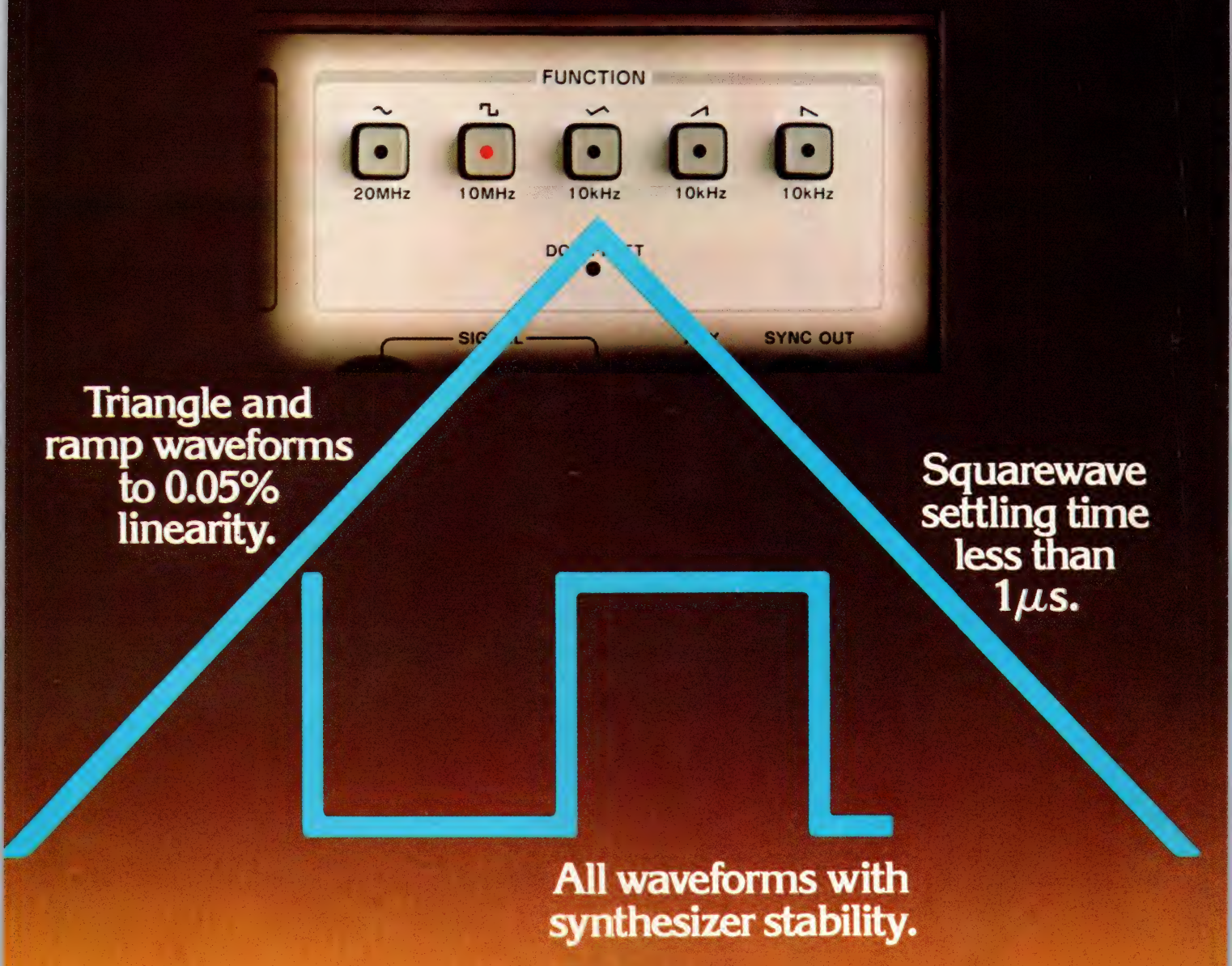
- A horizontal bandwidth of dc to 350 MHz
- Rise times of less than 350 psec
- A photographic writing speed of 20 cm/nsec
- Sweep triggering to 1 GHz
- Vertical sensitivity of 10 mV/div to 1V/div
- Full-size display (70×85 cm).

Versatile configurations

Another important feature of the 7104 is its compatiblity with all Tektronix 7000 Series plug ins. The mainframe can accept up to four modules, so you can configure it as a general-purpose scope, a spectrum analyzer or one of many other specialized instruments. (Three additions to the manufacturer's plug-in line specifically support the 7104: the 7A29 vertical amplifier and the 7B10 and 7B15 time bases.)

A typical working oscilloscope system—consisting of the 7104 mainframe plus the 7A29, 7B10 and 7B15 plug ins—costs $19,485.

Tektronix Inc, Box 500, Beaverton, OR 97007. Phone (800) 547-1572; in Oregon, 644-9051. **Circle No 453**



Triangle and ramp waveforms to 0.05% linearity.

Squarewave settling time less than 1 μs.

All waveforms with synthesizer stability.

HP's new 3325A Function Generator gives you all this precision for only $3,000*. And it's programmable, too.



Now, the precision functions you need cost less with HP's new 3325A Synthesizer/Function Generator.

The 3325A provides pushbutton selection of sinewaves, squarewaves and triangles as well as positive and negative ramps. Each function has the same high accuracy, stability and resolution you'd expect from a synthesizer. With its performance characteristics fully specified over the entire operating range.

That means you can obtain triangles and ramps from 1 μHz (periods to 11½ days), up to 11 kHz with 0.05% linearity. In applications such as VCO testing, you're assured of more conclusive results.

For amplifier analysis and precision timing and gating, the 3325A furnishes squarewaves over a range of 1 μHz to 11 MHz with less than 1 μs settling time to less than 0.05%. But that's not all.

Sinewave harmonics are down 65 dB (to 50 kHz) for low-distortion audio and VLF/ULF testing. Integrated phase noise is also low, at −54 dBc up to 20 MHz—just right in developing multiplex communication systems and phase sensitive networks.

Linear and logarithmic sweep are provided for all functions. Other standard features include HP-IB** capability for programmable control, variable phase and DC offset, and external AM and PM modulation capability. An optional 40Vpp high voltage output is also available.

For further details on HP's new 3325A Synthesizer/Function Generator, contact your local HP field engineer today. Your designs deserve precision.

* Domestic U.S.A. price only.

** HP's implementation of IEEE Standard 488-1975.

099/42

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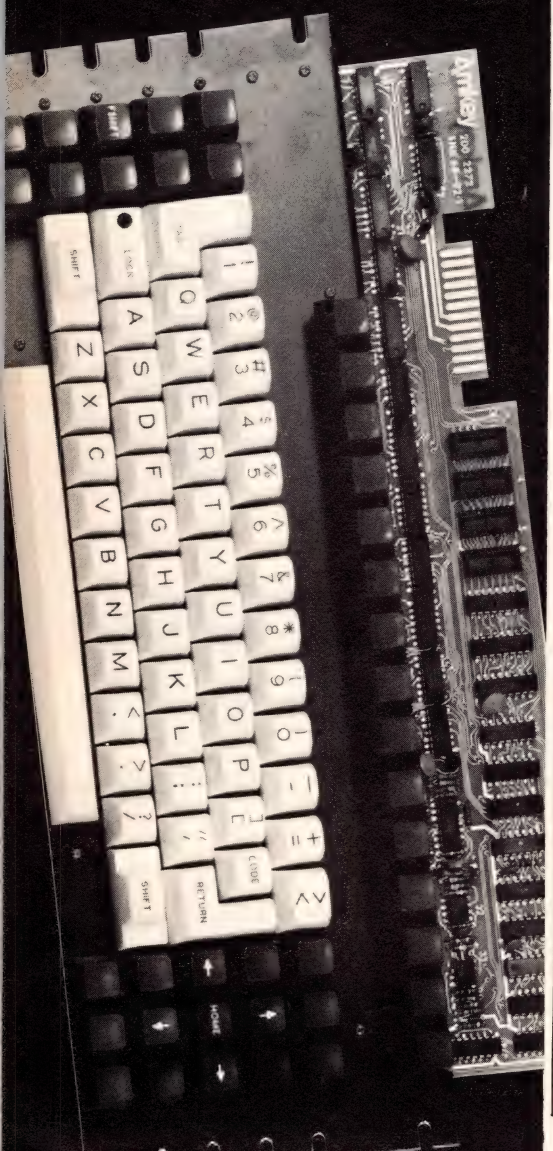
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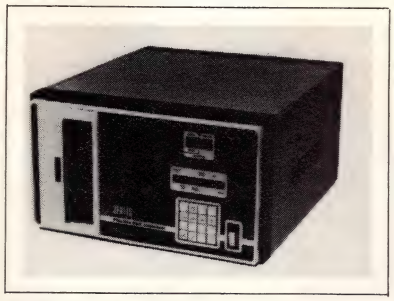
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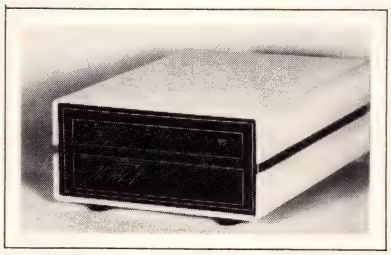
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New Products

COMPUTERS & PERIPHERALS

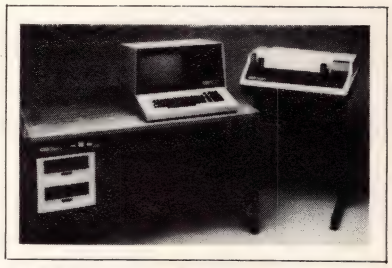


DISC INITIALIZER. Insert a floppy disc, push the Start Initialize button and in less than 45 sec the 3PX119 formats all 77 tracks with appropriate sector-ID and data fields, records the index track and verifies the entire disc's format. The self-contained unit accepts any 8-in. floppy disc and generates 128-, 256- or 512-byte sectors in any IBM-compatible soft-sectored format. $12,750 with three standard formats. **Three Phoenix Co,** 10632 N 21st Ave, Phoenix, AZ 85029. Phone (602) 944-2222. **Circle No 260**



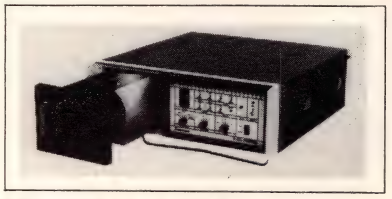
TERMINAL STORAGE. Providing off-line data storage (up to 12k characters) and editing, TSU Series units feature variable top of form and programmable answerback. All commands to enter, print or edit data are in English, and all units communicate with a terminal over an RS-232 interface. $300 to $1350. **Tri-Data Corp,** 505 E Middlefield Rd, Mt View, CA 94043. Phone (415) 969-3700.
Circle No 261

SERIES/80 RACKMOUNT. Accepting up to eight Series/80 μC, memory and interface boards, the RMC 660 comprises two system-board chassis, a power supply and a front panel with switches, all mounted in a standard RETMA enclosure weighing 49 lbs. Power, bus and control lines interconnect with etched backplane circuits, thereby allowing customer expansion. $1250. **National Semiconductor Corp,** Computer Products Group, 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-6593.
Circle No 262



DATA-ENTRY STATION. The stand-alone Model 20 provides 64k bytes of memory, a CRT terminal and two double-density floppy-disc drives, all incorporated into a wooden desk unit. A 150/180-cps printer handles output in 132 columns. $19,900. **Computer Systems Development Inc,** 4154 Crossgate Dr, Cincinnati, OH 45236. Phone (513) 984-6622. **Circle No 263**

TYPING SYSTEM. Capable of storing and handling up to 256 pages, the No Problem LC provides typing and editing functions for the production of multipage reports, manuals, technical publications and other documents. The system consists of an electronic keyboard, video display, disc-storage unit and high-speed printer. A single-disc system costs $16,900. **Lanier Business Products Inc,** Atlanta, GA 30324. Phone (404) 329-8000.
Circle No 264



PRINTER/MONITOR. Designed to monitor, print and document actual network data and test procedures, the D-201 also serves as a peripheral to its manufacturer's D-500 and 600 monitors. It oversees asynchronous lines at 50 to 9.6k bps. Fully portable, the D-201 measures 5.25×16×17 in. and weighs <28 lbs. $4500. **Spectron Corp,** 344 New Albany Rd, Moorestown, NJ 08057. Phone (609) 234-5700.
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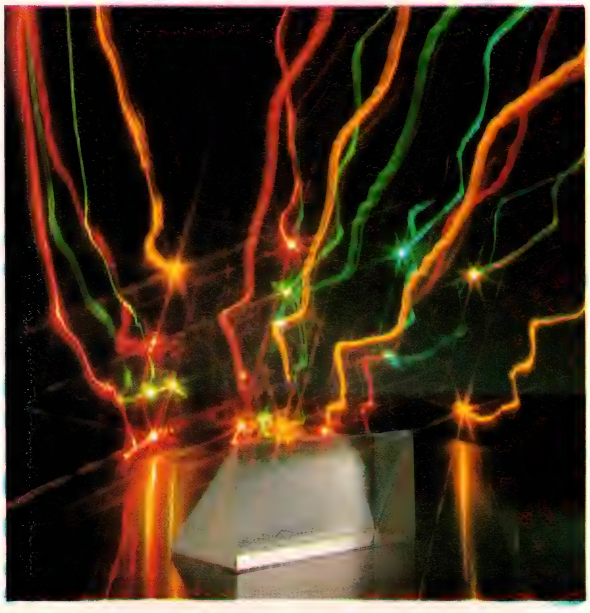
Part Number	Current Transfer Ratio %	Voltage	Description	No. of Channels
IL-1	20	2500	Photo Transistor	1
IL-5	50	2500	"	1
IL-15	6	1500	"	1
IL-74	12.5	1500	"	1
4N25	20	2500	"	1
4N26	20	1500	"	1
4N27	10	1500	"	1
4N28	10	500	"	1

Part Number	Current Transfer Ratio %	Voltage	Description	No. of Channels
4N32	500	2500	Photo Darlington	1
4N32A	500	2500	"	1
4N33	500	1500	"	1
IL-100	1000	2500	High Speed 75 nS	1
IL-101	1000	1500	High Speed 200 nS	1
ILCT6	20	1500	Photo Transistor	2
ILD74	12.5	1500	"	2
ILQ74	12.5	1500	"	4

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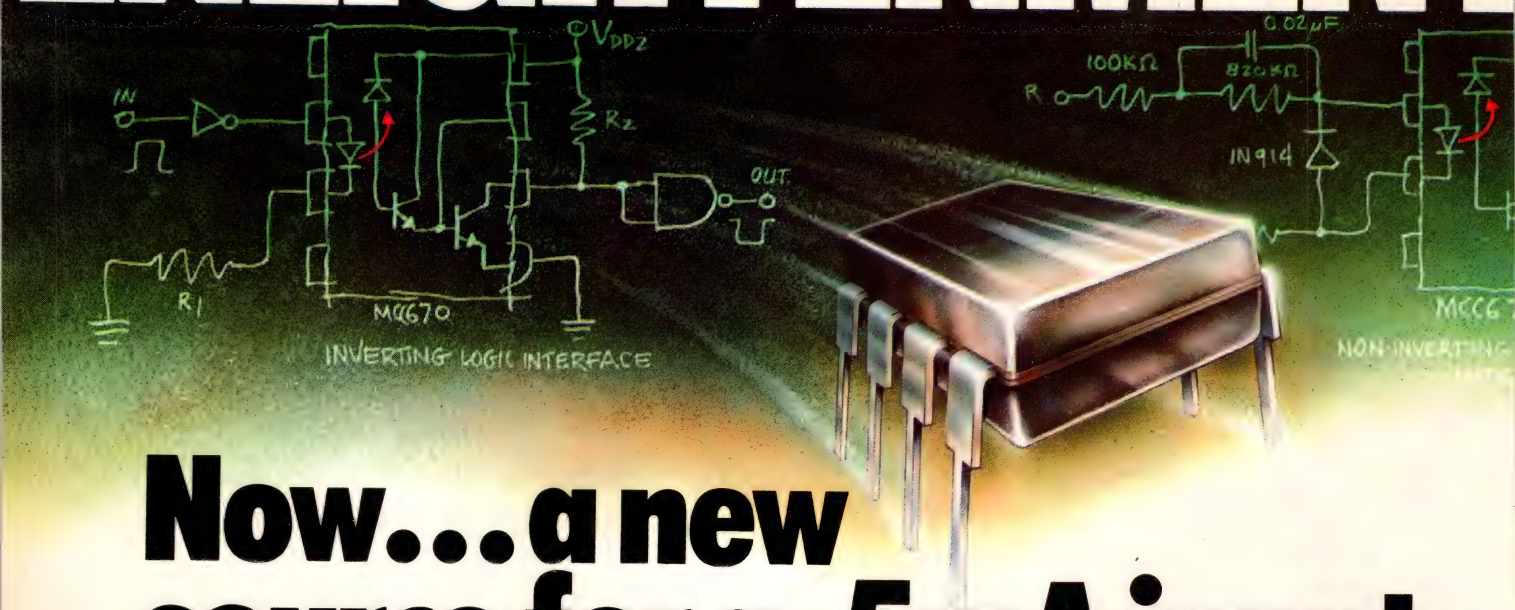
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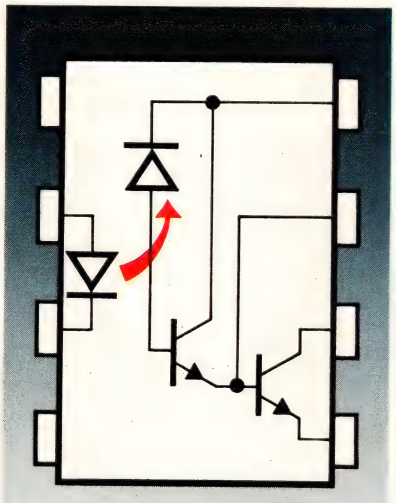


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New Products



CONTROL/DISPLAY UNIT. Simplifying the control and operation of μP- and minicomputer-based industrial test equipment, Model HT/2 suits applications where a hand-held controller is required. Operating on one 5V supply, the unit internally develops the 12V required for its RS-232C interface. Incorporating a simple keyboard, the device can transmit and display all 128 ASCII characters and control codes and operates in either full- or half-duplex modes. The display provides 2 lines of 10 0.27-in.-high characters per line. Priced at $1995 (1 to 9), the controller carries a full 1-yr warranty. **Termiflex Corp,** 17 Airport Rd, Nashua, NH 03060. Phone (603) 889-3883. **Circle No 266**

BIG-PRINT PRINTER. The Model 511L serial impact dot-matrix printer provides enlarged, 3.1 mm high characters and 6-mm line spacing. Suitable for printing tickets, the device operates at 2.2 lines per sec. The printer features a life expectancy of 5×10^6 lines MCBF (mean cycles before failure) and a printhead life of 100×10^6 characters. Each of the printhead's 7 wires has 480 dot positions available, with 240 dots printable per wire per line. $230. **C Itoh Electronics Inc,** 280 Park Ave, New York, NY 10017. Phone (212) 682-0420. **Circle No 267**

GANGED PROGRAMMER. Based on its manufacturer's PPX universal programmer, the PPG ganged programmer accepts ganged modules for all popular EPROMs. It handles up to 15 EPROMs at a time; several test sequences ensure proper functioning of data and address paths, power supply and RAM. Individual LEDs identify faulty EPROMs, while an alphanumeric display characterizes the fault. **Stag Systems,** 2465 E Bayshore, No 329, Palo Alto, CA 94303. Phone (415) 324-1564. **Circle No 268**

CASSETTE RECORDER. The Minicorder is an incremental digital recording system that accepts synchronous data without buffering circuits. Available options convert the unit to a low-power, read/write data-logging recorder. Both CMOS and TTL compatible, the recorder reads files at 100 cps and stores up to 72k characters. Automatic load forward, backspace, fast rewind and search provide ease of operation. $500. **Memodyne Corp,** 220 Reservoir St, Needham Heights, MA 02194. Phone (617) 444-7000. **Circle No 269**

DOCUMENTATION SOFTWARE. A group of Databus programs that executes on Datapoint Datashare systems, DOCGEN prompts its user to enter system and program information, thereby creating a document that includes overview narrative, equipment configuration, system and flow diagrams, user's guides and file/record definitions. As a front end to Datapoint's DSCRIBE and MSCRIBE utilities, it automatically embeds special output-control characters. $1750 for a license agreement. **EFAX Corp,** Computer Systems Div, 880 N York Rd, Suite 202, Elmhurst, IL 60126. Phone (312) 279-9292. **Circle No 270**

VIDEO I/O SOFTWARE. Written for compatibility with its manufacturer's Flashwriter I video board, the Extended Video Input/Output System (EVIOS) maximizes the capabilities of any video terminal and provides complete control over every facet of software programming. It furnishes cursor-motion commands, selective erase, reverse video, horizontal and vertical lines, graphics and reduced intensity. $75 covers manual, examples, source listing and 2708 PROM. **Vector Graphic Inc,** 31364 Via Colinas, Westlake Village, CA 91361. Phone (213) 991-2302. **Circle No 271**

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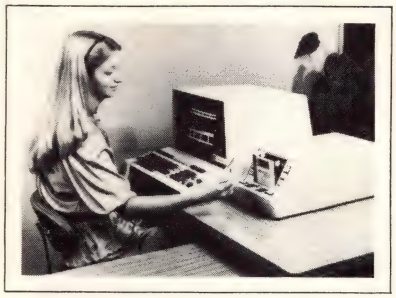
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New Products



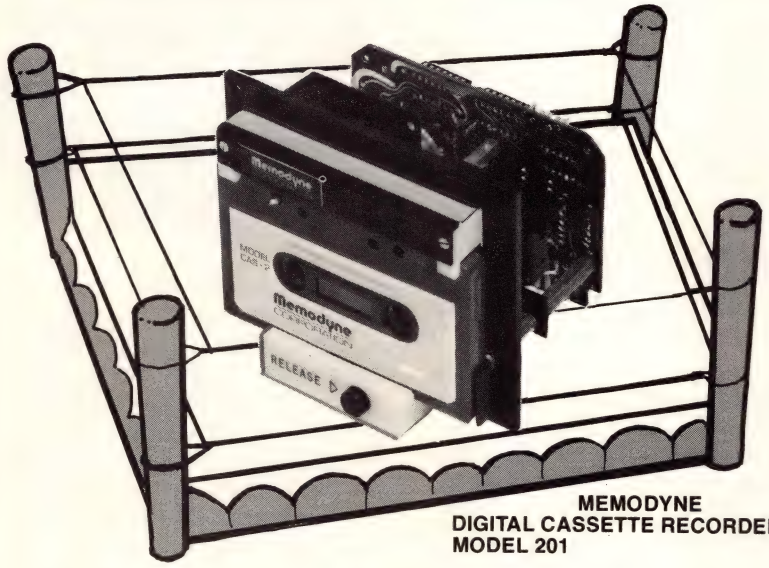
DATA ENTRY. Complete formats consisting of line drawings and 16 different types of display attributes can be flashed on the Video 200's screen to aid operators in entering data correctly. A cassette tape provides 50k-character buffering and transmits at 1200 baud. Editing features accommodate character/line insertion or deletion and the erasure of a full page or field. $161 per month, on a 3-yr lease (including maintenance). **Western Union Data Services,** 70 McKee Dr, Mahwah, NJ 07430. Phone (800) 631-7050. **Circle No 272**

CARTRIDGE RECORDER. Plug-compatible with the standard IEEE-488 bus, the GPIB 3000 provides data recording and playback capabilities for a wide range of instrumentation and data-acquisition systems. The unit employs a direct-drive servo motor for high quality tape handling. Recorded cartridges meet ANSI standard X3B5/75-44 for serial 1600-bpi recording. $3620. **Tandberg Data Inc,** 4060 Morena Blvd, San Diego, CA 92117. Phone (714) 270-3990. **Circle No 273**

μC TRAINING AID. Utilizing an 8085, Model 5036A teaches hardware, software and troubleshooting to technicians not familiar with μC systems. A 20-lesson handbook takes the user through a series of experiments that provide hands-on experience. A color-coded circuit board highlights components and buses; LEDs display the action on the data and address buses. $800. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-1501. **Circle No 274**



IMAGE PRINTER. Combining CRT and fiber-optic technology with a plain-paper, dry-toner copying process, the Image Printer can output 18 pages/min. It supports three type styles on-line; additional optional fonts are software loadable. The image system provides 90,000-dots/in.^{2} resolution to accommodate the most difficult print jobs. $35,000; a monthly maintenance contract costs $400/mo. **Wang Laboratories Inc,** One Industrial Ave, Lowell, MA 01851. Phone (617) 851-4111. **Circle No 275**



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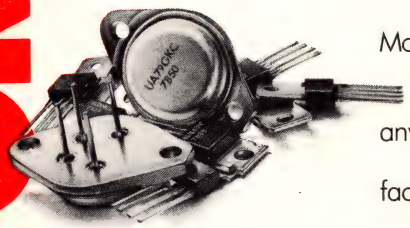
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μA78GU1C	4	1.0 A	Pos.	1.10	U1C
μA79GU1C	4	1.0 A	Neg.	1.10	U1C
μA317UC	3	1.5 A	Pos.	1.50	TO-220
μA337UC*	3	1.5 A	Neg.	1.50	TO-220

*Available mid-1979

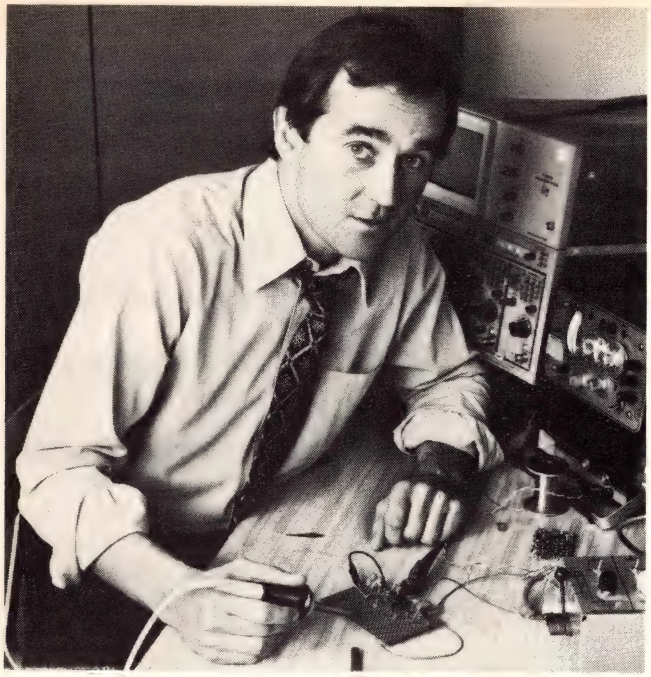
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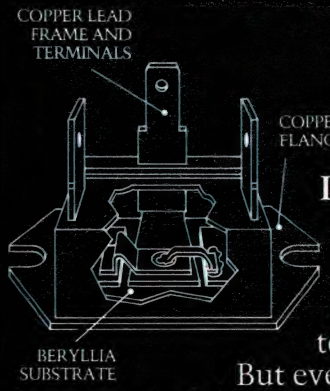
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Unitrode's new 25A ChipStrate triacs have the quick-connect, solderless terminals you need to cut production time and cost. But even more important, they have a typical thermal resistance of 1°C/W junction-to-case, resulting in higher thermal conductivity and reduced thermal stress. This means they'll run cooler and more reliably in your application.

The reason for this performance is Unitrode's exclusive ChipStrate manufacturing process. We start with a metalized beryllia substrate and then add a single-piece copper lead frame/terminal and glass-passivated triac chip.

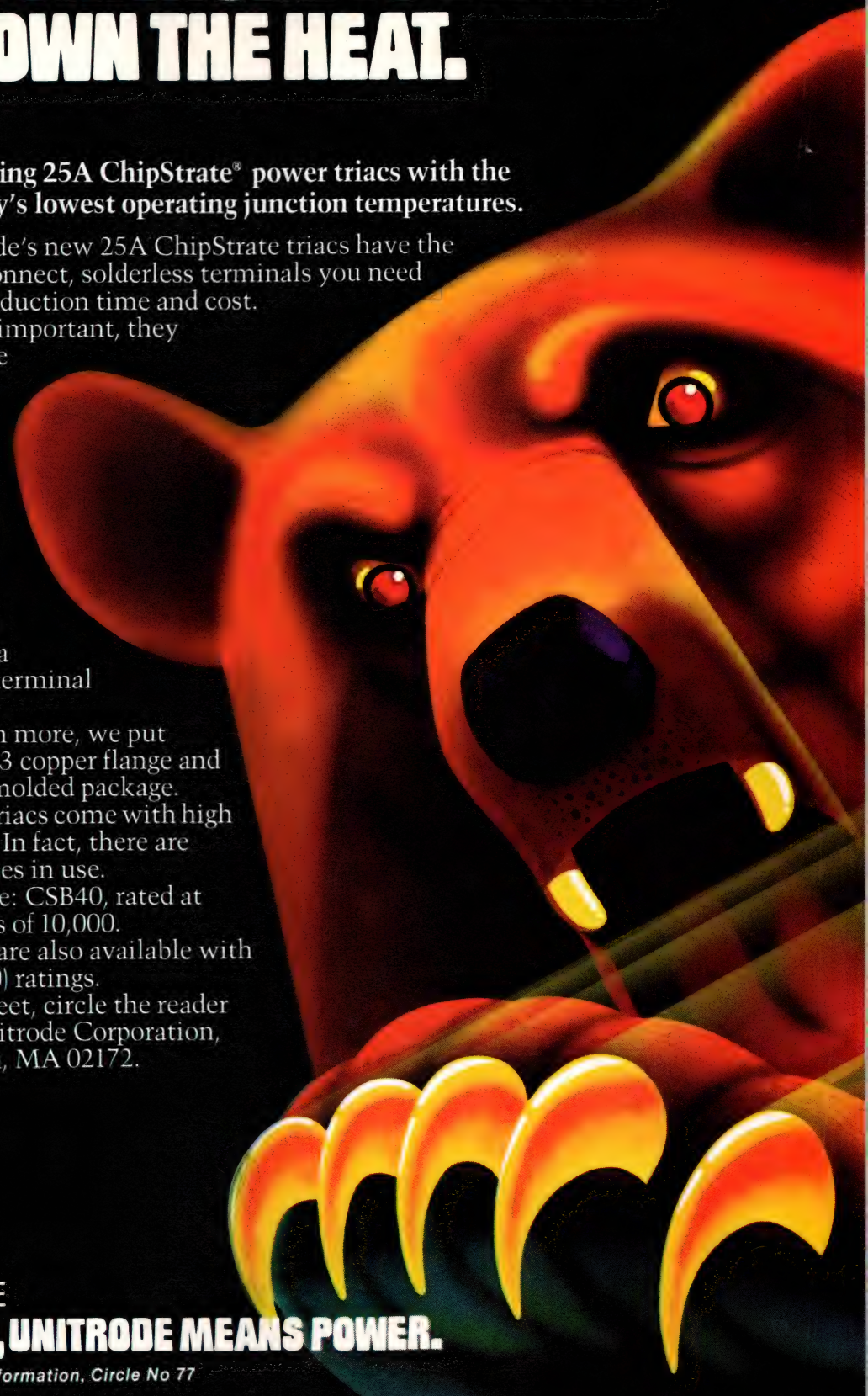
To increase performance even more, we put our ChipStrate triac onto a TO-3 copper flange and encapsulate the assembly in a molded package.

All this means that our new triacs come with high reliability and long life built in. In fact, there are over 4 million ChipStrate devices in use.

Yet our prices are competitive: CSB40, rated at 400V, is only $2.15 in quantities of 10,000.

Unitrode's 25A power triacs are also available with 200V (CSB20) and 600V (CSB60) ratings.

For a free sample and data sheet, circle the reader service number, or contact: Unitrode Corporation, 580 Pleasant Street, Watertown, MA 02172. Tel. 617-926-0404.



UNITRODE

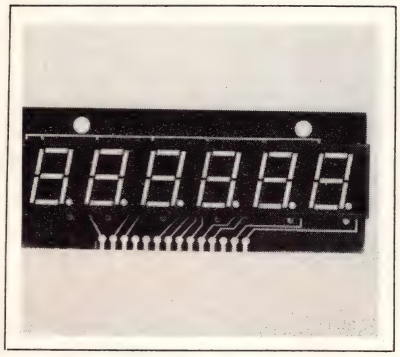
IN SEMICONDUCTORS, UNITRODE MEANS POWER.

For more information, Circle No 77

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New Products

COMPONENTS & PACKAGING



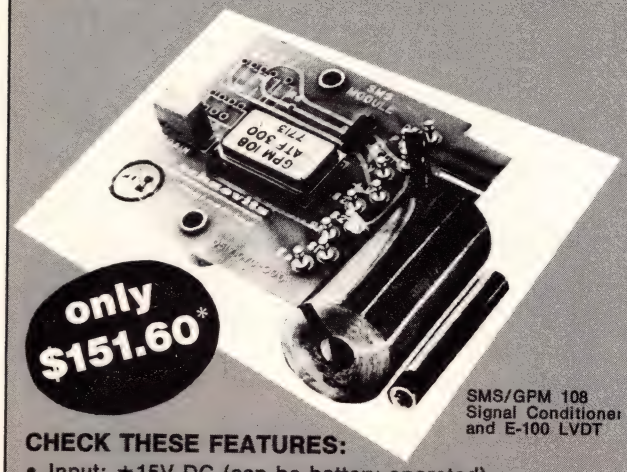
DISPLAY. Designed for simple multiplex operation, the NSB5931 is a 6-digit, 0.5-in.-high GaAsP LED display described as a form, fit and function replacement for the Litronix DL6500. Each digit is matched for brightness and contains a right-hand decimal point. This pc-board-built unit includes a plastic reflector and lens cap. Average current in each segment specs at 20 mA. The unit employs an edge-board connector for terminations. $10.80 (25). **National Semiconductor Corp,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-5000. **Circle No 166**

R NETWORKS. Series HC and HF devices are constructed of high-stability cermet resistors deposited on an alumina substrate in economical SIPs. The units are offered in 4-, 6-, 8-, 10- and 14-pin packages and four seated heights—0.2, 0.25, 0.3 and 0.35 in. Resistance values range from 33Ω to 470 kΩ with ±2% tolerances. Both isolated and one-pin-common resistor configurations are standard. $0.19 (25,000) for an 8-pin, 7-resistor unit. Delivery, 6 to 8 wks ARO. **Centralab Electronics,** 5757 N Green Bay Ave, Milwaukee, WI 53201. Phone (414) 228-2851. **Circle No 167**

SOCKET BOARDS. Designed to handle Schottky TTL, Series SCH13 wire-wrappable panels feature a center V_{CC} plane and two outside ground planes. They are supplied in groups of 30 16-position patterns per section and are available in from one to eight sections with either 26 I/O pins or 24 I/O socket terminals per section. All boards allow for decoupling capacitors at each DIP location. Universal versions (50 socket terminals per column) are also offered. $1.50 to $2 per IC position. **Garry Mfg Co,** 1010 Jersey Ave, New Brunswick, NJ 08902. Phone (201) 545-2424. **Circle No 168**

SWITCHES. Series SE2AV spst slide-action DIP switches feature nonslip actuation and easy flux-solvent flush-out. Available in two through 10 positions, they have dust-tight construction for the slide mechanism and a glass-filled polyester case. Gold-plated nickel over heat-treated beryllium-copper contacts and terminals have a carrying capacity of 100 mA at 50V ac, an operating range of 0 to 70°C and a 10,000 mechanical-operation lifetime. $0.74 to $3.15, depending on qty. **Cutler-Hammer Inc,** 4201 N 27th St, Milwaukee, WI 53216. Phone (414) 442-7800. **Circle No 169**

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CHECK THESE FEATURES:

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- 0.5% linearity over a 0.200 inch displacement range
- SMS/GPM module available individually at $132.80 each

**OEM quantities even lower*

Write for application bulletins on Schaevitz Signal Conditioning and Displacement Measurement Systems.

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P.O. BOX 505, CAMDEN, NEW JERSEY 08101

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Bowmar's low cost TP-3120 Thermal Printer... Now it does even more

Bowmar's quiet and economical TP-3120 thermal printer does a lot more than many of the others for a lot less. Small in size, yet big in capabilities, it's equipped with a host of superior quality Bowmar features.

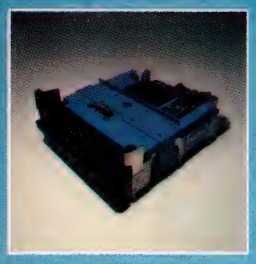
- Alpha/Numeric Printout
- 29.4 Characters Per Second
- Low Power Consumption
- MOS Compatibility.

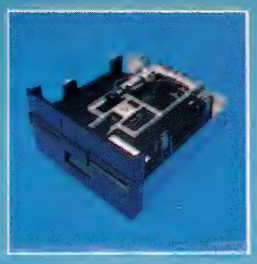


Bowmar

Bowmar Instrument Corporation
8000 Bluffton Road
Fort Wayne, IN 46809
Phone: (219) 747-3121

For more information, Circle No 79







Reliability in precision technology.

Looking for precision DC motors that save time, trouble and money?

You'll save time with AIRPAX because you'll find a large variety of DC motors available with just one phone call to us. We have brushless kits, iron rotor and ironless rotor motors in many sizes and performance ratings. (In fact, many of our ironless rotor models can save you even more time because 100 piece quantities are available from stock.)

You'll save trouble because AIRPAX motors are precision components designed for long life. The brushless type can be electronically driven for accurate speed and they feature low RFI. The iron rotor type is a "workhorse" motor that offers good efficiency and rugged construction. The ironless rotor features low cogging, high efficiency, excellent acceleration and an optional tach that gives you precise speed control.

Finally, you'll save money. All are remarkably low priced in production quantities. For example, one of our reversible 12VDC ironless rotor models, with a 29 millimeter diameter is just $16.00 in 500 piece lots!

For complete information on AIRPAX brushless, iron rotor or ironless rotor DC motors for computer peripherals and instrumentation, contact AIRPAX/North American Philips Controls Corp., Cheshire Industrial Park, Cheshire, CT 06410. Telephone: (203) 272-0301.



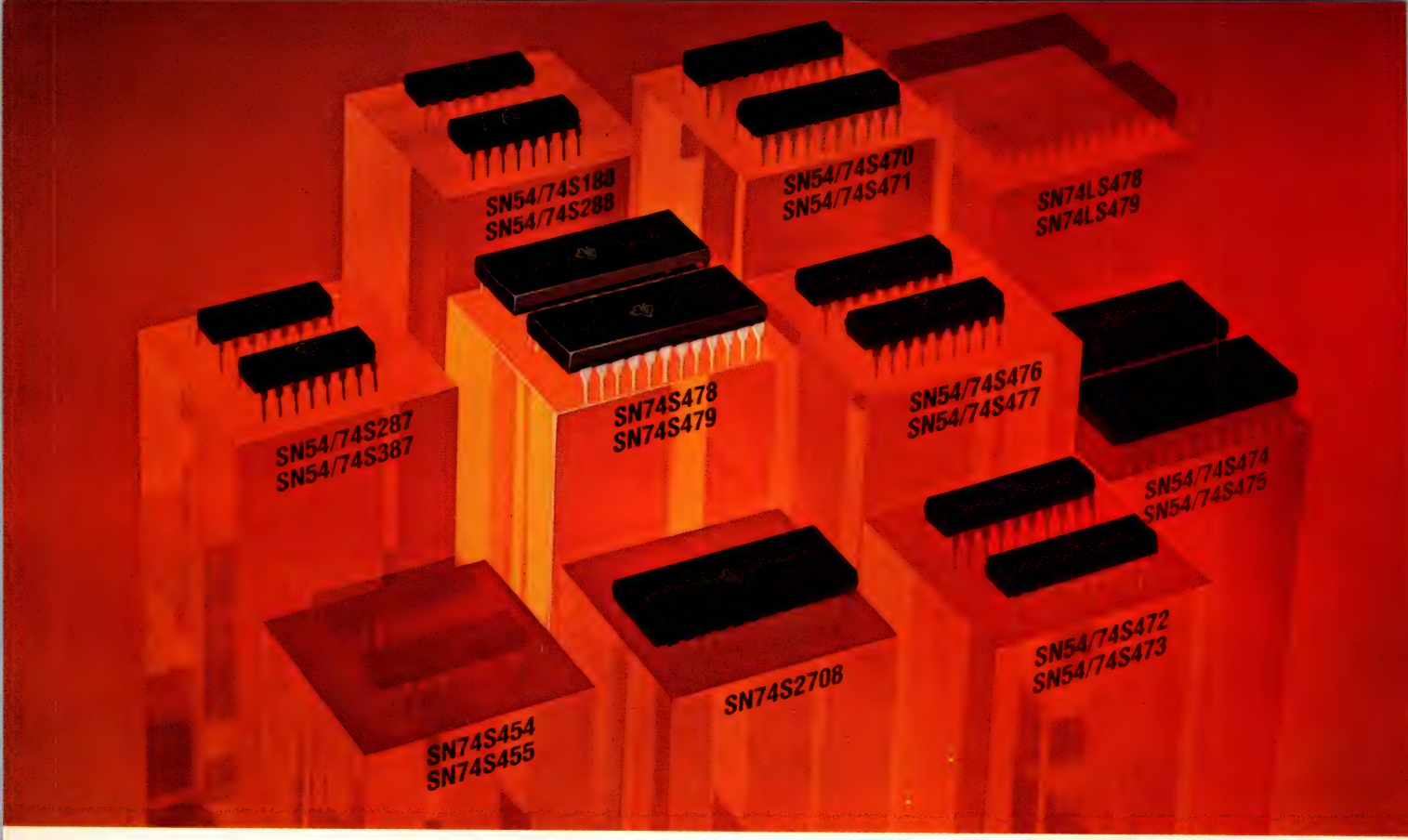
AIRPAX®

NORTH AMERICAN PHILIPS CONTROLS CORP.

Cheshire Division

For immediate need Circle No 80
For reference only Circle No 81

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Check 'em out: TI's new 8K Schottky PROMs. Greater density. Greater performance.

You double memory capacity. To 8K. And get a speedy 45 ns typical access time. With the new SN74S478 and SN74S479 Schottky PROMs from Texas Instruments. Available now for evaluation.

Yet, power dissipation is about half that of two 4Ks—630 mW typical.

These new high performance PROMs are organized by 8—especially attractive for microprocessor-based designs. They offer socket compatibility with TI's 24-pin S474 and S475 4K PROMs. And you can upgrade from other 4K configurations with minimum design changes. Price: only $19.35 each in 100-piece quantities in plastic DIPs. Outputs can be either three-state (S478) or open-collector (S479).

Another family addition

Now available is TI's new 8K SN74S2708 PROM. Switch to it for production after you've programmed with TI's TMS2708 EPROM. You'll gain faster throughput, greater stability, higher temperature capability.

TI's growing choice

The new S478, S479 and S2708 further expand TI's leadership in memories. You now have a choice of 15 PROMs. In 18, 20 and 24-pin plastic or ceramic packages. With by 4 and by 8 organizations.

Proven programming techniques are available for all. Low current pnp inputs permit interfacing with MOS and bipolar microprocessors. Titanium-tungsten fuse links speed programming, improve reliability.

More PROMs coming: On the way are low-power versions of the S478 and S479—the LS478 and LS479. Also, two 8K PROMs organized 2K by 4 in 18-pin packages—S454 and S455.

To check out the new S478 and S479, call your nearest TI distributor or TI field sales office. For a copy of TI's Schottky Memory brochure, write Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

TI'S BROAD PROM FAMILY

Device	Description
SN74S478	1024 W x 8B, 3-S, 24 Pins
SN74S479	1024 W x 8B, 0-C, 24 Pins
SN74S2708	1024 W x 8B, 3-S, 24 Pins
SN54/SN74S476	1024 W x 4B, 3-S, 18 Pins
SN54/SN74S477	1024 W x 4B, 0-C, 18 Pins
SN54/SN74S474	512 W x 8B, 3-S, 24 Pins
SN54/SN74S475	512 W x 8B, 0-C, 24 Pins
SN54/SN74S472	512 W x 8B, 3-S, 20 Pins
SN54/SN74S473	512 W x 8B, 0-C, 20 Pins
SN54/SN74S470	256 W x 8B, 0-C, 20 Pins
SN54/SN74S471	256 W x 8B, 3-S, 20 Pins
SN54/SN74S287	256 W x 4B, 3-S, 16 Pins
SN54/SN74S387	256 W x 4B, 0-C, 16 Pins
SN54/SN74S188	32 W x 8B, 0-C, 16 Pins
SN54/SN74S288	32 W x 8B, 3-S, 16 Pins

TEXAS INSTRUMENTS MOVING AHEAD IN MEMORIES

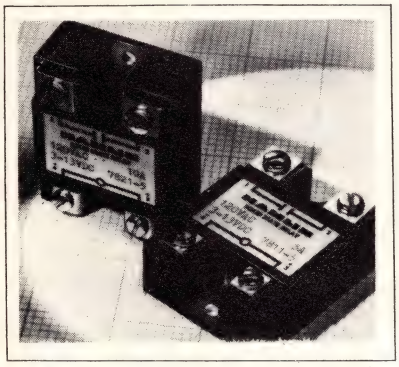
TEXAS INSTRUMENTS
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For more information, Circle No 82

New Products



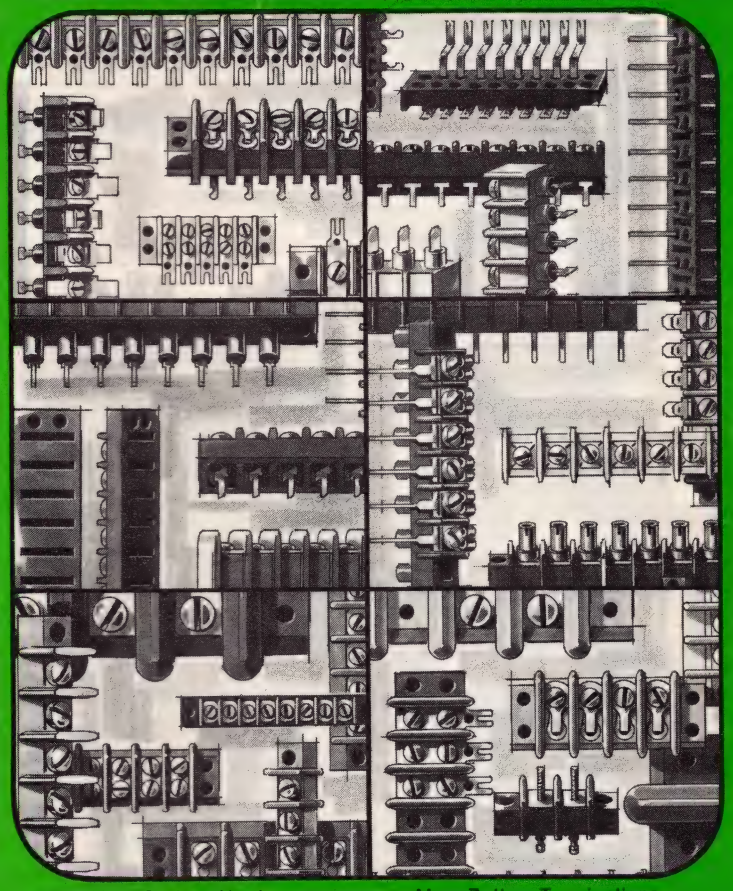
SS RELAYS. Low-cost hybrid designs, Series 7800 relays are available in 5, 10, 25 and 40A capacities. A variety of ac load-switching capabilities is offered: 24-140V with 200V blocking, 24-280V with 400V blocking and 24-280V with 600V blocking. Other specs include a 10^8 operation lifetime, 1-cycle surge-current ratings to 400A, 2500V rms isolation and −30 to +80°C operating range. These random-switching logic-compatible units feature a diode clamped input and internal RC snubber. $5.82 (1000) for 5A/24-140V unit. **Hamlin Inc,** Lake & Grove Sts, Lake Mills, WI 53551. Phone (414) 648-2361. **Circle No 170**

AMPLIFIER. A hybrid design housed in a 16-pin DIP, the VV100B has a gain of 10 and a −3-dB bandwidth of 230 MHz. With rise time <2 nsec and a 2500V/μsec skew rate, it drives a 25Ω load to −5V with ±0.1% linearity. Input noise is <4.2 nV/$\sqrt{\text{Hz}}$, and total input drift and offset over a 0 to 70°C range is <1 mV. $65. **LeCroy Microcircuits Div,** 700 S Main St, Spring Valley, NY 10977. Phone (914) 425-2000.
Circle No 171

RF MODULES. These three series of devices provide attenuation (MAR), resistor (MFR) and termination (MTR) functions up to 1 GHz with 50W input-power capability. The attenuator line offers six values ranging from 1 to 20 dB. The resistors and terminations are both available in five values from 12.5 to 100Ω. Packaged for stripline applications, all units include nichrome resistor elements, thin-film construction, beryllium-oxide substrates and copper heat sinks. $12 (100). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-6900.
Circle No 172

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powercon 6®

Sixth National Solid-State Power Conversion Conference and Exhibit

May 1-4, 1979
Fontainebleau-Hilton Hotel
Miami Beach, Florida

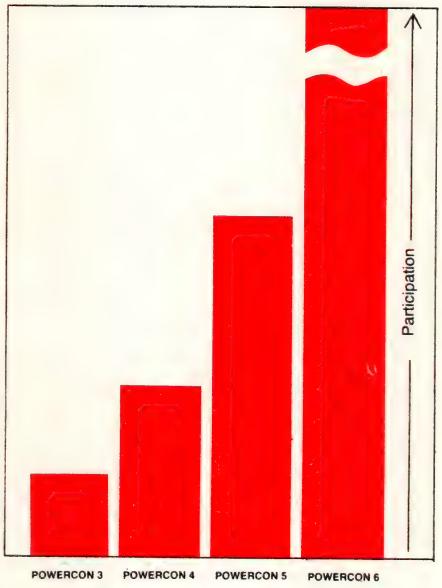
Some facts about POWERCON...

Over 85% of the attendees at a POWERCON conference are practicing engineers and engineering managers.

POWERCON conferences, seminars and tutorial exhibits are designed by practicing power conversion technologists, like you. That means we know what you need most.

A POWERCON must be *experienced*, for the value of even the most exemplary technical presentation cannot begin to compare to the catalytic effect of being among, and comparing notes and experiences with, the hundreds of your contemporaries who attend.

The participation in POWERCON's has more than doubled each year since 1976. And POWERCON 5 sold out.



POWERCON. Once a technical luxury. Now a professional and practical necessity.

The Conference.

Sixth in a series of annual national technical conferences devoted exclusively to the practical design and application of solid-state power conversion equipment and components. Emphasizing the modern trend to switched-mode and other "non-dissipative" technologies, the POWERCON 6 conference offers a comprehensive and intensive three-day examination of the latest and most important developments in the power conversion field.

- Three full days of technical presentations.
- Over 30 papers, presented by outstanding authorities.
- Nine sessions, chaired by distinguished experts.
- VMOS...Proportional drive... Sinewave synthesis...Micro-processors as feedback elements...Controlled resonant conversion...Reliability... Computer-aided design... High voltage...EMI... Non-dissipative load-line shaping...Motor control...plus much, much more.

The Tutorial Exhibit

Informal tutorial and "hands-on" (fully instrumented and working) demonstration exhibits presented by technologists from over 50 major suppliers in and to the power conversion field. Each exhibit is specifically configured to enhance your technical expertise through improvement of your detailed knowledge of the supplier's technology and processes.

- Investigate working circuits and waveforms.
- See new devices in action.
- See working demonstrations of new power conversion topologies.
- See new instrumentation and test equipment for power conversion.
- Magnetics. Capacitors. EMI/RFI. Heat transfer. IC's and hybrids. Complete power supplies and inverters. Motor controls.
- and much, much more.



Plus...a new Professional Advancement Seminar Program.

Designed to provide in-depth coverage of those topics most essential to the power conversion specialist, POWERCON 6 Professional Advancement Seminars offer designers, managers and users a comprehensive selection of invaluable learning opportunities under the direction of some of the world's leading authorities.

- Power converter circuit modeling, analysis, and measurement.
- Shaping and controlling feedback loop response.
- Assessing and controlling power converter EMI.
- High frequency magnetics... materials and design.
- Ultra-high-frequency power converter design.
- An introduction to switched-mode design.
- Automated testing and functional specification of power supplies.
- ...and for those in the "business end" of the field, a special market awareness seminar.

In the interest of providing a quality learning experience, seminar registrations will be limited, and may not be available to last-minute registrants.

For information, Circle No 158

Hotel Headquarters for POWERCON 6...

The Fontainebleau-Hilton.

Located only 20 minutes from Miami International Airport, on Miami Beach, this world-famous resort hotel has been only recently refurbished by Hilton from the ground up. Combining the ultimate in pleasant surroundings with tennis, bowling, jacuzzis, an olympic-size swimming pool, incredible room rates, and an incomparable location on the Atlantic Ocean, Hilton has welcomed POWERCON 6 with open arms.

Special half-price room rates for POWERCON 6 attendees extend from 3 days prior to the conference until 3 days after:
Singles: $30-$35
Doubles: $35-$41

For further information concerning POWERCON 6, please call: (805) 985-6978 or (805) 486-5463.

POWERCON 6, PO Box 5226, Ventura, CA 93003

Gentlemen: Please rush complete POWERCON 6 program and registration information.

Name _____

Title _____

Company _____

Div./Dept. _____

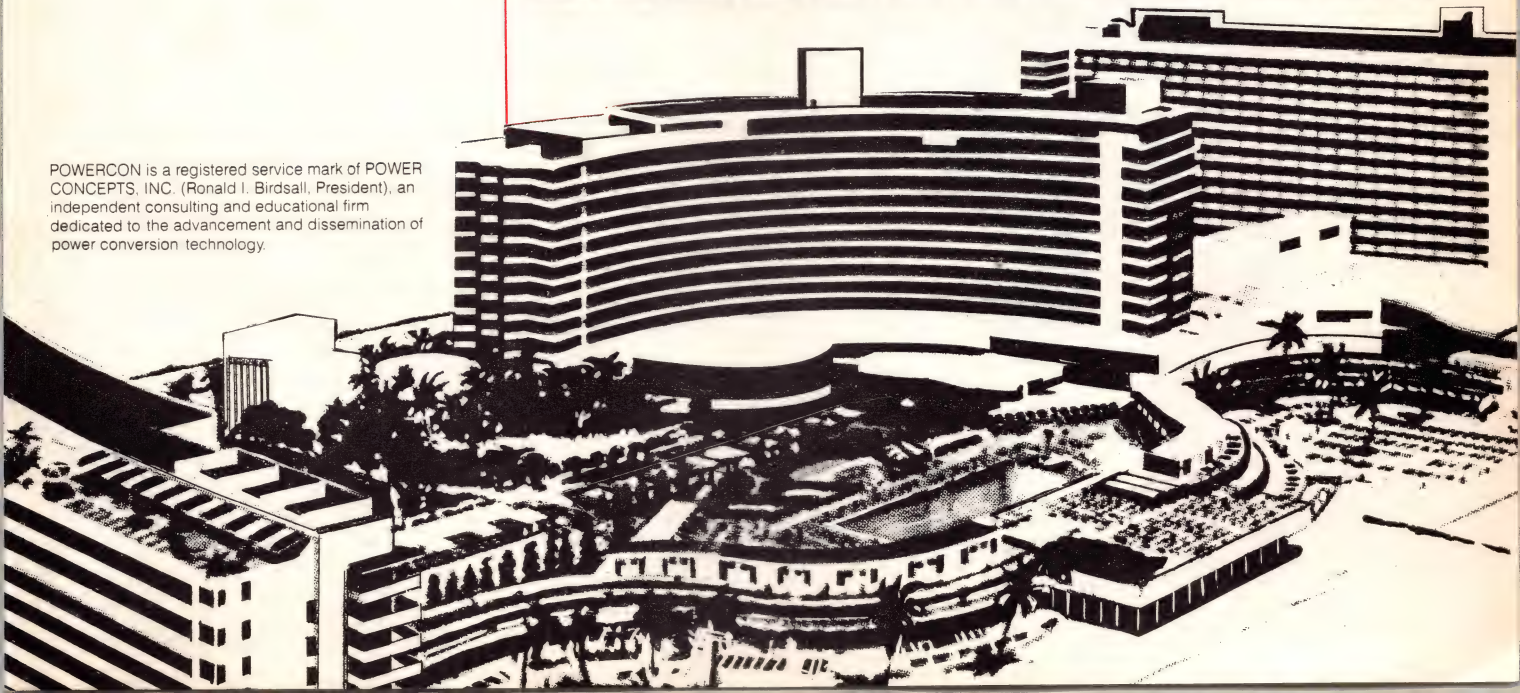
Address _____

City, State, Zip _____

Some of my colleagues may be interested in attending POWERCON 6. Please send them invitations.

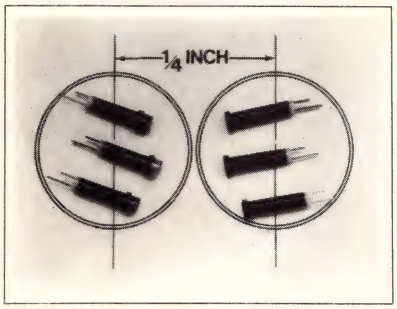
Name _____ **Title** _____

Name _____ **Title** _____

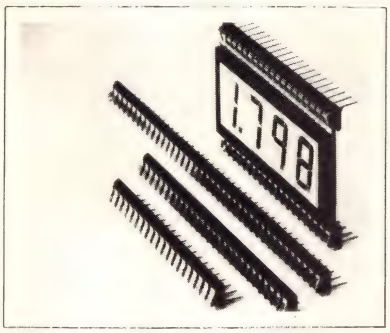


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New Products

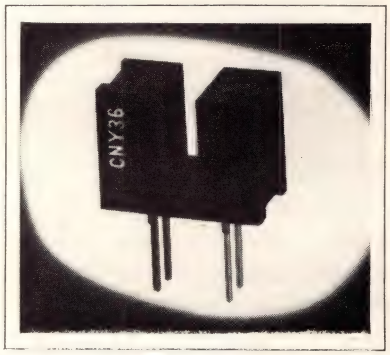


LEDs. Mountable on 0.25-in. centers, super-bright subminiature Series 30 LEDs fit in 0.19-in. mounting holes and feature wire-wrapping terminals. Luminous intensity (at a 20-mA drive current) for the red, amber and green lamps is 50, 32 and 25 mcd, respectively. Units come with regular or low-profile Fresnel lenses as well as clear or diffused standard LED encapsulation. Fresnel lenses can be supplied with legends. You can order the lamps with built-in resistors for operation from 2.4 to 28V dc. $1.39 to $1.48 (1000). **Data Display Products,** 303 N Oak St, Inglewood, CA 90301. Phone (213) 677-6166. **Circle No 175**



CONNECTORS. Series S420U units clip directly onto DIP-housed LCDs, eliminating the need for epoxy or frames when securing displays to pc boards. The connectors are supplied with up to 40 contacts (on 0.1-in. centers); these tin-plated brass-alloy contacts are integral with their corresponding pins and cast into the connector body. Connector bodies are made of rugged glass-reinforced thermoplastic polyester. $0.01 per contact (10,000). **Teledyne Kinetics,** 410 S Cedros Ave, Solana Beach, CA 92075. Phone (714) 755-1181.
Circle No 173

ATTENUATORS. Covering a range of dc to 2 GHz, Series 3300 miniature fixed attenuators are available in 28 standard nominal values from 0.1 to 100 dB. Designed primarily for OEMs, the units have VSWR of 1.15 max and typical accuracy (including frequency sensitivity) of ±0.3 dB. The attenuators have stainless steel bodies and WPM connectors (male or female) which mate with SMA type per MIL-C-39012. $15 to $25. Delivery, 45 days ARO. **Weinschel Engineering,** Gaithersburg, MD 20760. Phone (301) 948-3434. **Circle No 176**



INTERRUPTER MODULE. Featuring solid-state reliability and noncontact switching, the CNY 36 consists of a high-efficiency GaAs LED coupled with a high-gain silicon npn phototransistor across a 3-mm airgap. For a 20-mA input, output current is 0.5 mA and turn-on and turn-off times are 4 μsec each. The CNY 36 is encapsulated in a plastic package designed for easy mounting on a pc board and is available with a custom selection of electrical characteristics. $1.01 (5000). **Optron Inc,** 1201 Tappan Circle, Carollton, TX 75006. Phone (214) 242-6571. **Circle No 177**

CONNECTOR. This QUIP (quad in-line package) system includes a leadless 64-position ceramic chip carrier and both production and burn-in sockets. No insertion force is required to connect the carrier and socket, and mechanical polarization prevents improper carrier and/or socket insertion. The production socket has pins spaced on a standard 0.05-in. grid with 0.1-in. centers and provides top access for probe testing. The ZIF burn-in socket is rated for 200°C. **3M Co,** Dept EP8-8, Box 33600, St Paul, MN 55133. Phone (612) 733-9214.
Circle No 178

COUPLERS

More than a couple of reasons to buy our couplers.

To begin with, there's delivery. We gear our production capacity to keep ahead of your demand.

Then there's selection. Our line of single and dual couplers is one of the broadest on the market, with special emphasis on high-performance, general-purpose parts.



And of course, there's performance. Fairchild can meet most of your demanding requirements. For example, our "Glassolated"™ coupler features 5 kVdc standard isolation voltage. For more reasons, call us.

Or write Fairchild Camera and Instrument Corporation, P.O. Box 880A, Mountain View, CA 94042.
Tel: (415) 962-3088.
TWX: 910-373-1227.

FAIRCHILD

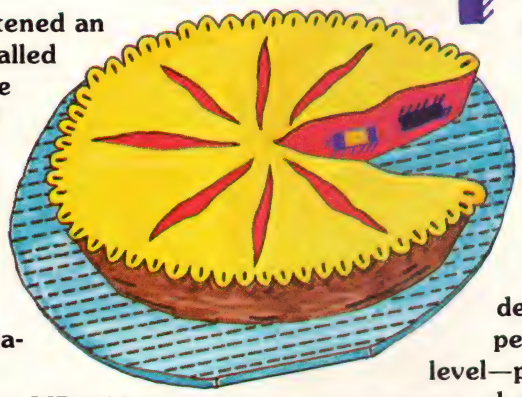
Call us on it.
(415) 962-3088

For more information, Circle No 85

Micro Power takes a slice of the 1K Static RAM pie.

Uses new HD/CMOS memory recipe.





Micro Power has sweetened an old pie with a new recipe called High Density/CMOS. We've carved out a small piece of the Static RAM market where ingredients like high quality, field reliability, on-time deliveries, performance stability and added product features are more important than some companies' left overs.

Our pantry is full of new MP6508 and MP6518 1K's just waiting to be served up. They're pin-compatible and look like they came out of the same pan as the Intersil IM6508. We'll wrap the MP6508 up any way you want, with plastic, CERDIP, and ceramic to meet your commercial, industrial, and military tastes.

Look at the added performance we've whipped up for the MP6508 without having to pay any more. There are competitive prices for each part down at the store. You'll like the 300ns access speed for reading data in or out. This speed enables your memory system to work at the same rate as your 8080 microprocessors. These units approach a maximum voltage of 7 volts, so you can forget about burnt crusts when using four, fully-charged 1.5 V batteries in portable product applications. If you're tired of sticking your finger in every pie to determine its true standby supply current value, then you'll love our spicy little current—10μA max and typical 1μA or less when the devices are idle or in the non-switching state.

Drop by our kitchen sometime and take a look at Micro Power's chief cook and bottle washers—they've been cooking up RAMs in custom LSIs for years. They've always been ahead in digital and analog circuitry with precision bipolar, NMOS, PMOS and CMOS state-of-the-art recipes. Now they're into HD/CMOS cuisines for memories. These secret recipes use two-layer metal interconnects, silicon-nitride passivation and other proven techniques that are industry acknowledged enhancers of reliability and low power. If reliability, quality, delivery, predictable leakage, and more performance—all at a competitive price level—puts a good taste in your mouth, then you probably fit into Micro Power's slice of the RAM pie. Our Chef, Frank Berko, wants you to sample the MP6508. We think you will be pleased with our very impressive engineering specifications for the new recipe memories. Send coupon or call Frank at (408) 247-5350, ext. 270.

ENGINEERING SPECIFICATIONS

Device	Memory Config.	Access Time	Standby current Max.	Standby current Typical
MP6508, 18	1K x 1	300ns	10μA	1μA
*MP6504	4K x 1	300ns	10μA	1μA
*MP6514	1K x 4	300ns	10μA	1μA

*Second quarter sample deliveries

3100 Alfred Street
Santa Clara, CA 95050
(408) 247-5350

MICRO POWER SYSTEMS

To: **Micro Power Systems,** 3100 Alfred St., Santa Clara, CA 95050

☐ Send 1K HD/CMOS Static RAM technical data
☐ Send data on upcoming 4K HD/CMOS Static RAM

Name

Title

Company

Address

City State Zip

For more information, Circle No 86



* 100's, cable not included.

HERE'S A $99* LINK TO ISOLATED, ERROR-FREE TTL DATA TRANSMISSION

This fiber optic data link offers the lowest cost alternative to achieve total electrical isolation and noise immunity. 3712T transmitter (TTL In/Light Out) and 3712R receiver (Light In/TTL Out), coupled by fiber optic cable, form a simplex data link. You're assured of reliable, error-free 20k bit data transmission through hostile, noisy environments.

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DC coupled, 3712R is designed for low noise, low drift and maximum sensitivity. It requires only 5nW optical power and ±15VDC (±20mA). 3712T requires +5VDC (+60mA max) and launches 3.5μW of optical power into a 40mil, 0.53 N.A. fiber.

Metal packages (1.6″ x 3.0″ x 0.6″) increase noise immunity and are suitable for PC board or connector mounting. Link operating temperature is 0 to +70°C.

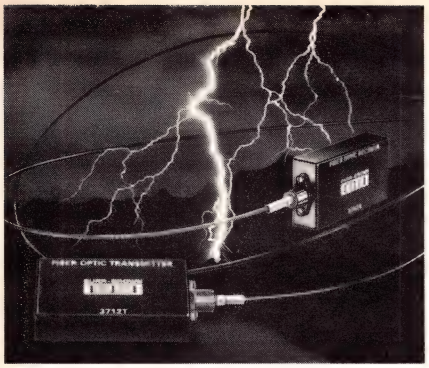
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(602) 746-1111.

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SPECIAL
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20-feet fiber optic cable (with connectors)

Two electrical connectors

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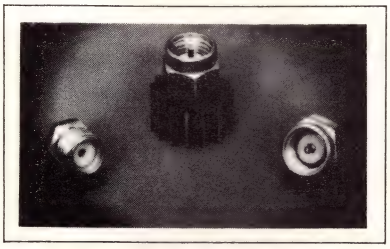
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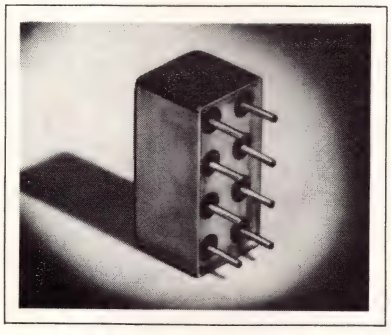
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New Products

R NETWORKS. A family of precision thin-film ladder networks, Series D355 units provide an R-2R configuration for A/D and D/A converters. The DIP-configured networks provide either 10- or 12-bit resolution over full temperature ranges (0 to 70 or −55 to +125°C). With 12-bit models, accuracy is ±0.012% (1/2 LSB) and temperature tracking is better than 1 ppm/°C. **Electro Films Inc,** 100 Meadow St, Warwick, RI 02886. Phone (401) 738-9150. **Circle No 179**



TERMINATION. The PCX-SM-1 50Ω SMA termination can be ordered with various levels of VSWR performance: 1.1 from dc to 4 GHz, 1.12 from 4 to 8 GHz and 1.15 from 8 to 18 GHz. The ruggedized unit has an average power rating of 1 kW, which doubles when a semiconductor-type heat sink is used. Male or female connectors are supplied. $10.75. **KDI Pyrofilm Corp,** 60 S Jefferson Rd, Whippany, NJ 07981. Phone (201) 887-8100.
Circle No 180



COUPLER. A quadrature device, Model QSP-101 operates from 55 to 95 MHz. Over the full range, typical insertion loss and isolation specs are 0.3 dB and 35 dB, respectively. All ports have a 1.1 VSWR. The QSP-101 is available in a standard 8-pin plug-in package (0.4×0.4×0.8 in.) which meets environmental specs of MIL STD 202E. $18. **Engelmann Microwave Co,** Skyline Dr, Montville, NJ 07045. Phone (201) 334-5700.
Circle No 181

SS RELAY. Filling out the company's Serendip line, the solid-state 642 is an optically coupled ac relay which features zero-voltage switching to minimize circuit noise. One of the smallest zero-switching devices on the market, it is rated to switch up to 1.5A at 250V rms. Peak-transient protection ratings range to 600V. $7.55 (1000). **Teledyne Relays,** 12525 Daphne St, Hawthorne, CA 90250. Phone (213) 777-0077. **Circle No 182**

NOISE MODULE. Covering the range of 500 to 1000 MHz, the NOD45 operates from a 15V supply and uses <300 mA. It provides a minimum output of −82 dBm/√Hz across 50Ω and has a peak factor of >+12 dB. Over a 10 to 50°C range, TC is <0.01 dB/°C and, after warmup, long-term drift is <0.05 dB/24 hrs. The unit has an SMA connector for noise output, solder lugs for bias voltages and is housed in a rugged aluminum case. Delivery, 8 wks ARO. **Micronetics Inc,** 36 Oak St, Norwood, NJ 07648. Phone (201) 767-1320. **Circle No 183**

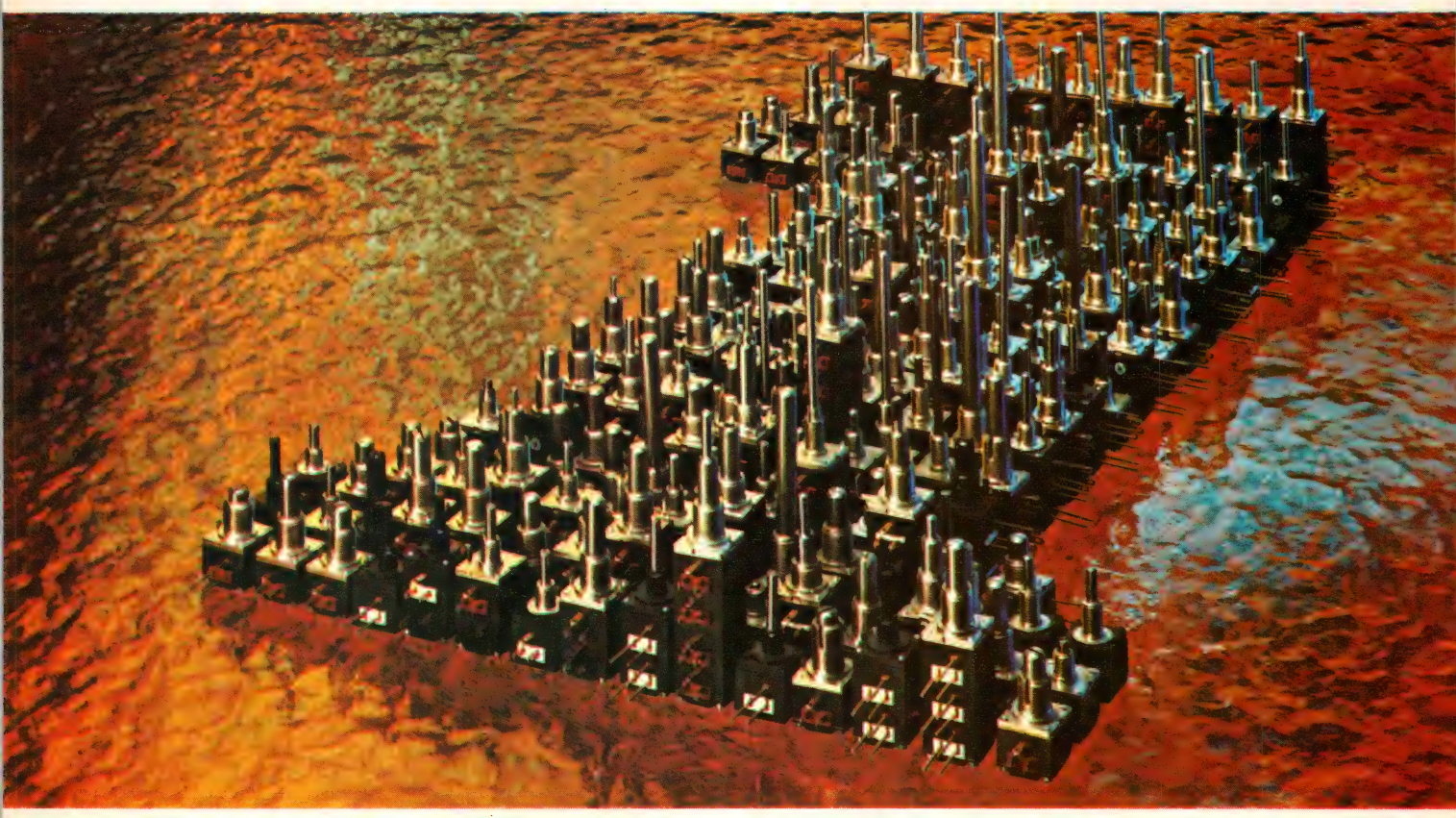
CAPACITORS. While small enough to be used in high-density circuits, Type 608/608T polyester-dielectric capacitors are built to withstand an axial-lead pull force >2 kg. Capacitance values range from 0.001 to 0.1 μF at 100V, and 0.012 to 2 μF at 50V. Tolerances of ±1 to ±20% are available; dissipation factor varies <1% from −50 to +125°C. $0.63 (1000) for a 0.001-μF, ±20%, 100V unit. **TRW Capacitors,** 301 West O St, Ogallala, NB 69153. Phone (308) 284-3611.
Circle No 184

SWITCHES. UL listed and CSA certified, these spst rocker and paddle switches are available with three separate ratings: 10A (Series 161), 12A (Series 162) and 16A (Series 163). Snap-in panel mounting allows installation without added hardware. A wide variety of color combinations, circuits (ON-OFF, momentary NO and NC), bezels, illuminated versions, hot stamping and custom colors are available. Slip-on type, 1/4-in. terminals can also be soldered. $0.35 (1000) for 10A, ON-OFF unit. **Chicago Switch Inc,** 1714 N Damen Ave, Chicago, IL 60647. Phone (312) 489-5500.
Circle No 185

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MOD POT,® the original modular potentiometer—available in over a billion combinations. A whole family of resistive elements: hot-molded composition, cermet, conductive plastic. Variety of switch options, vernier drives with solid or concentric shafts. Single, dual, triple or quadruple control sections. Solder lug or PC pins. Save panel space with ⅝" square module. Fast delivery backed by our distributor assembly centers. Ask for Publication 5217.

RESISTANCE ELEMENT	RESISTANCE RANGE	TOLERANCE	TAPERS	POWER RATING (LINEAR TAPER)		
				SERIES 70	SERIES 72	SERIES 73
Hot Molded Composition	50 ohms to 10 megs	±10% or ±20%	Linear (U)	1.0 Watt at 70°C	0.5 Watt at 70°C	0.75 Watt at 70°C
	250 ohms to 10 megs		Modified Log CW (A) or CCW (B)			
Cermet	100 ohms to 5 megs	±10%	Linear (U)	2.0 Watts at 70°C	1.0 Watt at 70°C	2.0 Watts at 70°C
	250 ohms to 1 meg		Modified Log CW (A) or CCW (B)			
Conductive Plastic	100 ohms to 1 meg	±10% or ±20%	Linear (U)	0.5 Watt at 70°C	0.25 Watt at 70°C	0.5 Watt at 70°C
	500 ohms to 1 meg		Modified Log CW (A) or CCW (B)			



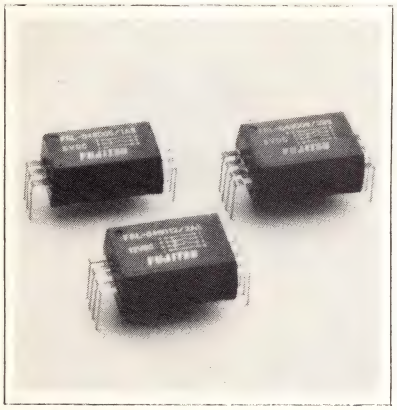
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A-B QUALITY

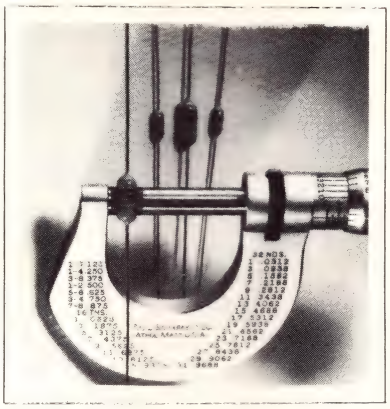
ALLEN-BRADLEY
Milwaukee, Wisconsin 53204

For more information, Circle No 88

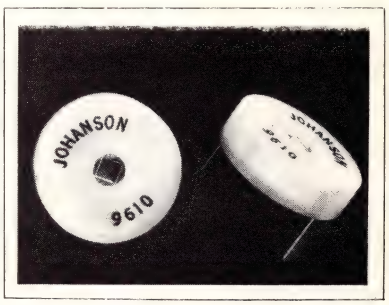
New Products



RELAYS. Epoxy-molded to provide immersion-cleaning safety and solid construction, low-profile FRL 640 reed relays come in 1 Form A, 1 Form B, 2 Form A and 2 Form B designs. Input-control voltage ratings of 5, 6, 12 and 24V dc are standard. Two levels of output-switching capability are offered: 50 VA max (100V ac, 0.5A max) and 10W (100V dc, 0.5A max) for heavy-duty applications. Optional magnetic shielding is available. $0.92 to $2.06 (1000). **Fujitsu America Inc,** 910 Sherwood Dr, Lake Bluff, IL 60044. Phone (312) 295-2610. **Circle No 186**



INDUCTORS. Compatible with automatic insertion machinery, Series IR-2 and IR-4 industrial-grade inductors are protected by a specially-applied flame-retardant epoxy coating which provides excellent dimensional uniformity and environmental protection. Inductance values range from 0.1 to 1000 μH for −2 units and 0.15 to 240 μH for the −4 devices. Both series are available in 1, 3, 5 and 10% tolerances. $0.17 (1000) for a 10-μH, 10% IR-2 inductor. **Dale Electronics Inc,** Box 609, Dept 860, Columbus, NB 68601. Phone (605) 665-9301. **Circle No 187**



CAPACITORS. Designed for pc-board mounting, this family of miniature, sealed ceramic trimmer capacitors offers a broad selection of capacitance values ranging from 1-4.5 pF (JMC9610) to 7-40 pF (JMC9614). All units provide high Q and low drift rates, and the JMC9615 employs NPO material for use in temperature-sensitive applications. The square-drive tuning mechanism insures captive, nonslip tamper-proof adjustments which are free of any backlash problems. The sealed body prevents solder and flux intrusion and atmospheric contamination. $1.15 (1000). **Johanson Mfg Corp,** 400 Rockaway Valley Rd, Boonton, NJ 07005. Phone (201) 334-2676. **Circle No 188**

Dial Prototype. (401)781-6500.

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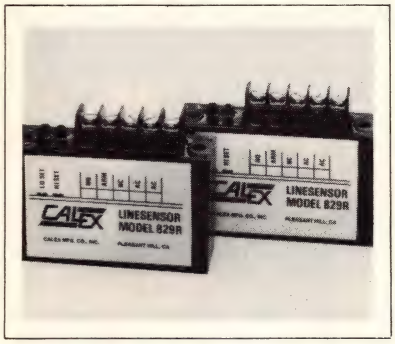
C&K snap-acting, momentary, miniature pushbutton switches with vertical support brackets respond to pressure with a positive feel and an audible sound. They install on P.C. boards quickly and easily and feature anti-stress support brackets that help to eliminate strain on terminals. Now everyone will get a good feeling from your designs.

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New Products



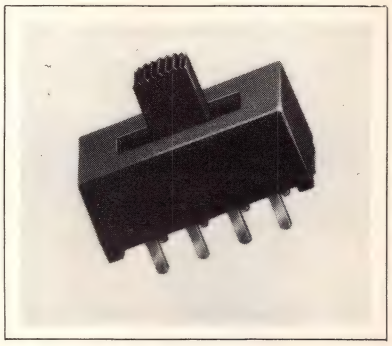
VOLTAGE MONITORS. Models 829R and 829T require no power supply because they operate on the line voltage being monitored. Both monitor the line for high and low limits which are set by pots molded into the case. When the voltage is within the limits, a high-voltage relay (-R) rated for 1A at 26V dc or 0.5A at 115V ac, or a photocoupled open-collector transistor (-T) is activated. Connections are made via terminal strips. Both modules are epoxy potted for ruggedness. $68 (R), $89 (T). **Calex Mfg Co Inc,** 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911.

Circle No 189



REFERENCE JUNCTION. Providing information on 10 thermocouple wire-termination pairs, the SL101 bonds a highly linear, stable, silicon thermometer to a carefully designed thermal shunt. It directly receives shielded-wire sizes up to 14 AWG and provides internal isothermal transition to copper conductors. Output sensitivity is 1 mV/°C, accurate to within 0.01° C/C and stable to 0.001° C/C/yr. Termination options include a choice of solder-eye or ribbon-cable edge connectors. $195 (3). **San Diego Instrument Laboratory,** 7969 Engineer Rd, San Diego, CA 92111. Phone (714) 292-0646.

Circle No 190



SWITCHES. Intended for low- to medium-current applications, the SL Series includes six types of enclosed wave-solderable slide switches in both detented and momentary spring-return designs. Buttons, housing and stators are 94-VO UL-rated, molded thermoplastic. Terminals (stationary contacts) are silver-plated phosphor bronze. The sliding contacts are also silver-plated (gold optional) phosphor bronze and feature a bifurcated design which makes contact on both sides of the terminals. $0.50. Delivery, 6 to 8 wks ARO. **Standard Grigsby Co,** 920 Rathbone Ave, Aurora, IL 60507. Phone (312) 844-4300. **Circle No 191**

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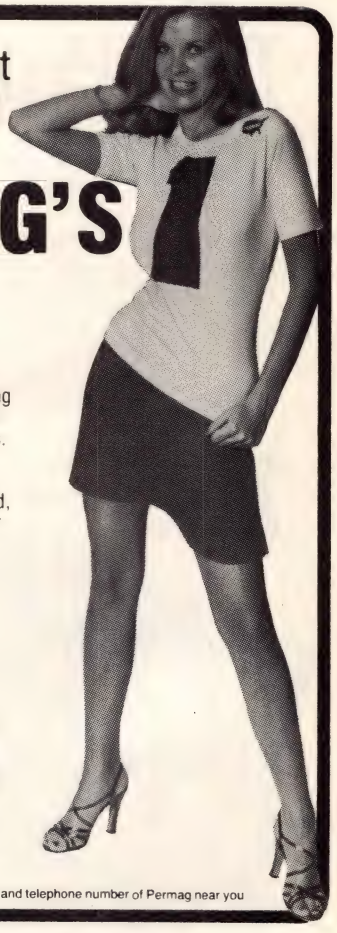
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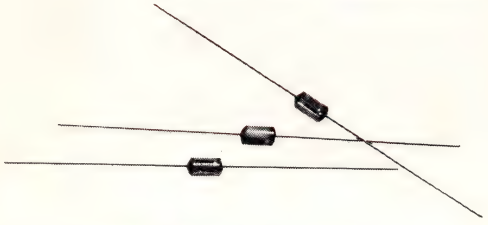


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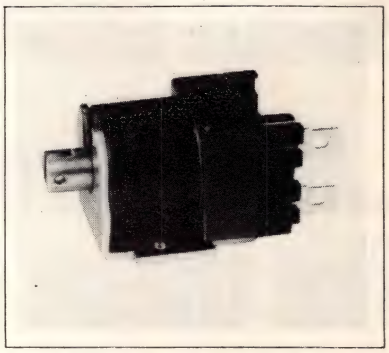
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New Products

RESISTORS. VHM-1 resistors are <0.25-in. in diameter and stand 0.2-in. high. Resistance values range from 50Ω to 20 kΩ, with tolerances to ±0.02%. Other specs include a working voltage of 45V, 2.5-ppm/°C TCR, 3-ppm/°C tracking, 0.08-μH inductance and <−32-dB noise. The units have load-life stability of 0.05% typical ΔR at full rated power (100 mW) at 125°C for 2000 hrs and shelf-life stability of 0.001% ΔR for 3 yrs. **Vishay Resistive Systems Group,** 63 Lincoln Hwy, Malvern, PA 19355. Phone (215) 644-1300. **Circle No 192**

FILTERS. Series MNF and MWF MIL-qualified bandpass filters are now available with center frequencies of 93, 124 and 165 kHz. MNF units are down <3 dB at ±7.5% of center frequency, with a 15-dB minimum at ±25% of that frequency. Attenuation is >40 dB at frequencies above 1.75 and below 0.58 times center frequency. MWF filters are down <3 dB at ±15% of center frequency, with a 15-dB minimum at ±50%. Attenuation for these filters is >40 dB at frequencies above 2.5 and below 0.4 times center frequency. $96.42. **TRW/UTC Transformers,** 150 Varick St, New York, NY 10013. Phone (212) 255-3500. **Circle No 193**

CONNECTOR. Providing solderless pc-board mounting of leadless ICs, the Chip Carrier connector consists of a plastic socket containing four elastomeric connector elements and a rotary lid. The connectors are available in three sizes (24/28, 52 and 68) and a choice of two elastomeric elements—Zebra and Conmet. The Zebra element is the preferred choice for low-power CMOS chips, while the Conmet elements best serve low-resistance and high-current applications. $0.33 and $0.45 (50,000) for the 24/28 size with Zebra and Conmet elements, respectively. **Technical Wire Products Inc,** 129 Dermody St, Cranford, NJ 07016. Phone (201) 272-5500. **Circle No 194**



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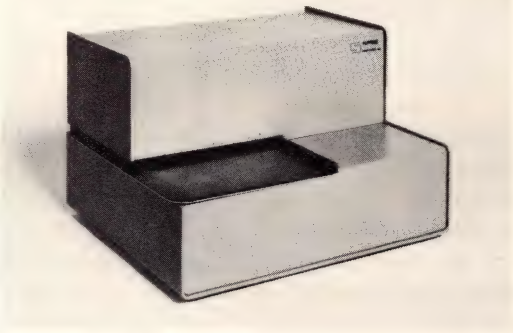
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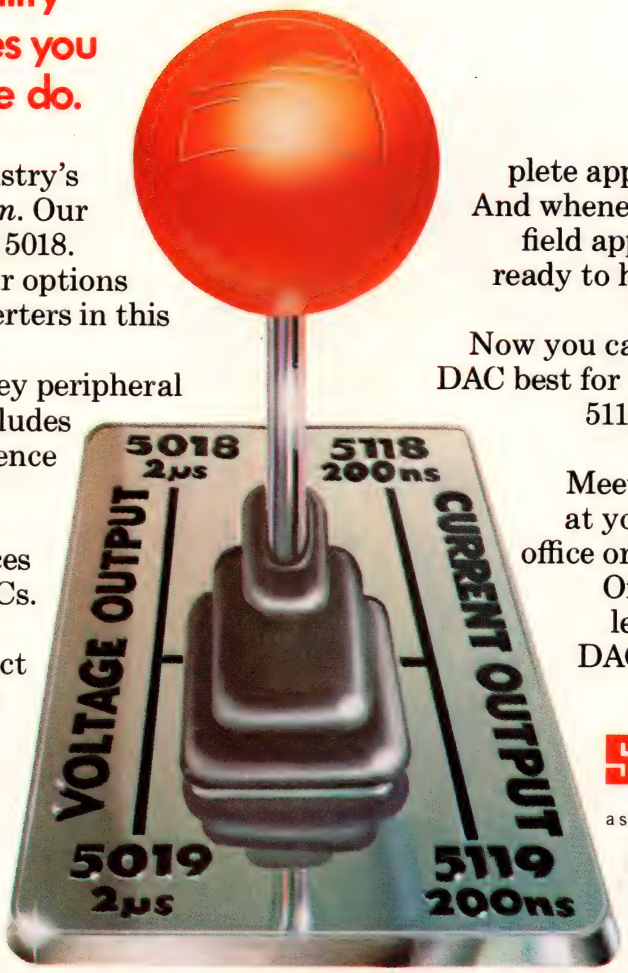
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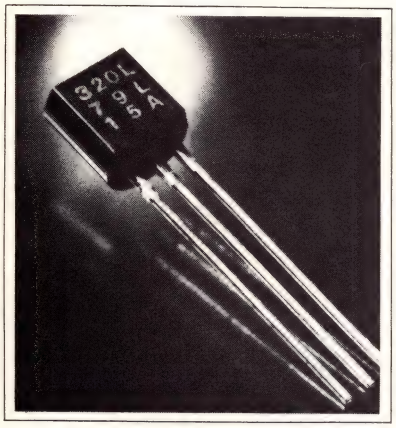
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New Products

ICs & SEMICONDUCTORS



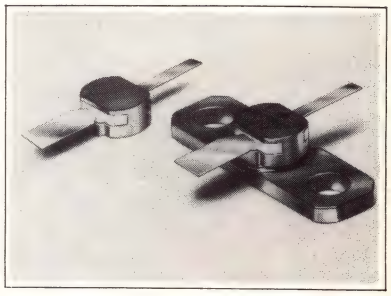
NEGATIVE REGULATORS. These two series of low-cost, fixed-output, 3-terminal negative voltage regulators feature high ripple and line rejection and tight load regulation. Series LM320L has output voltages of −5, −6, −8, −9, −12, −15, −18 and −24V and load-current capability of more than 100 mA. The 250-mA LM320ML series has the same voltages except for a −10V unit that replaces LM320L's −9V device.

LM320L units have line rejection of 0.07% V_{out}/V_{in}, quiescent current of 6 mA, 50-dB ripple rejection at −5V (46 dB at −24V) and load regulation of 0.01% V_{out}/mA. For the LM320ML, line rejection is better than 0.05% V_{out}/V_{in} with load regulation of 0.01% V_{out}/mA.

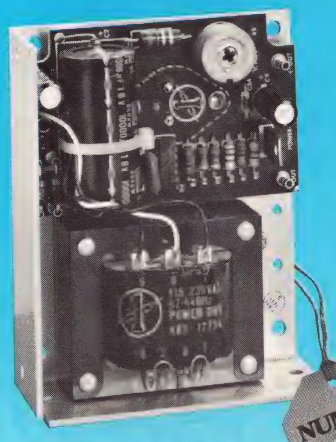
Both series offer preset output-voltage errors of less than ±5% over the rated load, line and temperature ranges. Capable of operation with 0.1 μF compensation capacitors, the devices include safe-operating-area circuitry, a temperature-independent short-circuit current limit and thermal shutdown circuits. Available in a TO-92 package, the LM320L costs $0.65 (100). The LM320ML costs $0.85 in a TO-202 package. **National Semiconductor Corp,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-5856. **Circle No 196**

POWER GHz TRANSISTORS. MRF2001, 03, 05 and 10 npn silicon power transistors serve Class B or C amplifier or oscillator applications. They have performance characteristics guaranteed at 2 GHz, 28V dc with output powers from 1 to 10W. All units are tested for load mismatch at all phase angles with 10:1 VSWR. In addition, the devices have gold metallization and emitter ballasting for long life and resistance to metal migration. Minimum gains range from 9 dB for the 1W MRF2001 to 6 dB for the 10W MRF2010. All units come in flange or pill packages. From $15.75 (100). **Motorola Semiconductor Products,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-6394.

Circle No 197



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CTS Corporation
Carlingswitch Inc.
Raytheon Semiconductor Division
Texas Instruments Inc., Connector Systems

Date_____ **Time**_____

Place_____







1979 EDN CARAVAN ELECTRONIC SHOW TOUR
February 12 to March 20 (first half)

DATE	TIME	SITE
2/12 AM	Monday 9-11	HEWLETT-PACKARD CO. 1400 Fountain Grove Pkwy, Santa Rosa, CA Main parking lot
2/12 PM	Monday 3-4	DIABLO SYSTEMS 26460 Corporate Av, Hayward, CA Bldg G prkg entrance
2/13 AM	Tuesday 8:30-10	HEWLETT-PACKARD CO. 1501 Page Mill Rd, Palo Alto, CA Bldg 5U visitor prkg area
2/13 AM	Tuesday 10:30-12	VARIAN ASSOCIATES 611 Hansen Way, Palo Alto, CA Near main security Bldg 2
2/13 PM	Tuesday 1:30-4	AMPEX CORPORATION 401 Broadway, Redwood City, CA Bldg 3
2/14 AM	Wednesday 9-12	FORD AERO & COMMUNICATIONS CORP. 3939 Fabian Way, Palo Alto, CA Across from Bldg 3 lobby
* 2/14 PM	Wednesday 1:30-4	WATKINS-JOHNSON CO. 3333 Hillview, Palo Alto, CA Inside gate, south side Bldg 4
* 2/15 AM	Thursday 9-11:30	HEWLETT-PACKARD CO. 5301 Stevens Creek Blvd. Santa Clara, CA. Lawrence Xway side of Bldg 52
2/15 PM	Thursday 1-3	MEMOREX CORPORATION San Tomas & Central Xway, Santa Clara, CA Bldg 10 near employee entrance
2/15 PM	Thursday 3:30-4:30	MEMOREX CORPORATION Memorex Dr, Santa Clara, CA T bldg, 1330 Memorex Dr
2/16 AM	Friday 9-11:30	AMDAHL CORPORATION 1250 E. Arques Av, Sunnyvale, CA Bldg M3
* 2/16 PM	Friday 1:30-3:30	ATARI INCORPORATED 1272 Borregas Av, Sunnyvale, CA Rear of prkg lot
2/19 AM	Monday 9-12	LOCKHEED MISSILES & SPACE CO. 1111 Lockheed Way, Sunnyvale, CA Bldg 151 entrance
* 2/19 PM	Monday 1:30-4	GTE SYLVANIA 123 N. Whisman Rd, Mountain View, CA Bldg 4 (100 Ferguson Dr)
2/20 AM	Tuesday 9-11	INTEL CORPORATION 3065 Bowers Av, Santa Clara, CA Near front entrance
2/20 PM	Tuesday 1:30-4	HEWLETT-PACKARD CO. 11000 Wolfe Rd, Cupertino, CA Shipping/rec'ving at Bldg 43
2/21 AM	Wednesday 8:30-10	ISS SPERRY UNIVAC 10435 N. Tantau St, Cupertino, CA West side, Bldg 3
2/21 AM	Wednesday 10:30-12	FOUR PHASE SYSTEMS, INC. 10700 N. DeAnza Blvd, Cupertino, CA NW corner of prkg lot
2/21 PM	Wednesday 2-3:30	FAIRCHILD INSTRUMENTATION SYSTEMS 1725 Technology Dr, San Jose, CA Adj SW corner of bldg
* 2/22 AM	Thursday 9-10:30	IBM CORPORATION 5600 Cottle Rd, San Jose, CA Adj Bldg 28
* 2/22 AM	Thursday 11-1 PM	IBM CORPORATION 5600 Cottle Rd, San Jose, CA Adj cafeteria
* 2/23 AM	Friday 8:30-10:30	BURROUGHS CORPORATION 6300 Hollister Av, Goleta, CA West side of front prkg lot
2/23 PM	Friday 1-2:30	BURROUGHS CORPORATION 5411 N. Lindero Canyon Rd Westlake Village, CA Main prkg lot, adj to bldg
2/23 PM	Friday 3-4:30	BUNKER RAMO CORPORATION 31717 LaTienda Dr, Westlake Village, CA East side near employees' entrance
* 3/5 AM	Monday 9-11:30	HUGHES AIRCRAFT CO. 8433 Fallbrook, Canoga Park, CA North lobby entrance, Bldg 268
3/5 PM	Monday 1:30-4	LITTON GUIDANCE & CONTROL SYSTEMS 5500 Canoga Av, Woodland Hills, CA Bldg 31 prkg lot
* 3/6 AM	Tuesday 9-11:30	DATAPRODUCTS CORPORATION 6219 DeSoto Av, Woodland Hills, CA Bldg 1 visitors prkg
* 3/6 PM	Tuesday 1:30-4	LITTON DATA SYSTEMS 8000 Woodley St, Van Nuys, CA Between Bldgs 40 & 45
3/7 AM	Wednesday 9-11	ITT GILFILLAN 7821 Orion Av, Van Nuys, CA Gate A
3/7 PM	Wednesday 1:30-3	BURROUGHS CORPORATION 460 Sierra Madre Villa, Pasadena, CA Prkg lot, north side of bldg
* 3/7 PM	Wednesday 3:30-4:30	BELL & HOWELL CO. 360 Sierra Madre Villa, Pasadena, CA Bldg C
3/8 AM	Thursday 9-11	GOULD, INC. 4323 Arden Drive El Monte, CA Pkg to be advised
* 3/8 PM	Thursday 12:30-4:30	HUGHES AIRCRAFT CO. Centinela & Teale, Culver City, CA N of trailers 3009, 3010
3/9 AM	Friday 9-11	XEROX CORPORATION 701 So. Aviation Blvd, El Segundo, CA Curbside, north lobby Bldgs A & E
3/9 PM	Friday 1:30-4	TRW DEFENSE AND SPACE SYSTEMS 1 Space Park, Redondo Beach, CA Visitor prkg lot, Bldg R4
* 3/12 AM	Monday 9-12	HUGHES AIRCRAFT CO. 1901 W. Malvern Av, Fullerton, CA Prkg to be advised
* 3/12 PM	Monday 2-4:30	BECKMAN INSTRUMENTS 2500 Harbor Blvd. Fullerton, CA Inside Gate 1, NE side
3/13 AM	Tuesday 8:30-10	INTERSTATE ELECTRONICS CORPORATION 707 E. Vermont, Anaheim, CA Curbside next to Bldg 708
* 3/13 AM	Tuesday 10:30-12	INTERSTATE ELECTRONICS CORPORATION 1001 Ball Rd. Anaheim, CA Behind engineering bldg
* 3/13 PM	Tuesday 2-4	NORTHROP CORPORATION 500 E. Orangethorpe Av, Anaheim, CA Bldg V/3 main gate
3/14 AM	Wednesday 9-12	ROCKWELL INT'L, AUTONETICS GROUP 3370 Miraloma Av, Anaheim, CA Prkg lot near Tower C
3/14 PM	Wednesday 1:30-2:30	CALIFORNIA COMPUTER PRODUCTS 2411 La Palma, Anaheim, CA Prkg lot N side engrg bldg
* 3/14 PM	Wednesday 3:15-4:30	CALIFORNIA COMPUTER PRODUCTS 1270 N. Kraemer Blvd, Anaheim, CA Between Bldgs C1 & C2
* 3/15 AM	Thursday 9-11:30	FORD AERO & COMMUNICATIONS CORP. Ford Rd, Newport Beach, CA Adj environmental test bldg
3/15 PM	Thursday 1:30-4	ROCKWELL INT'L. COLLINS DIVISION 4311 Jamboree Rd, Newport Beach, CA Prkg to be advised
3/16 AM	Friday 8:30-10	GENERAL AUTOMATION 1055 S. East St, Anaheim, CA Guard house, main receiving gate
3/16 AM	Friday 10:45-12	COMPUTER AUTOMATION 18651 Von Karman, Irvine, CA Adjacent to bldg
* 3/16 PM	Friday 2-4	BURROUGHS CORPORATION 25725 Jeronimo Rd, Mission Viejo, CA Side entrance, S side
3/19 AM	Monday 9-11	CONTROL DATA CORPORATION 4455 Eastgate Mall, La Jolla, CA Rear of bldg adj empl entrance

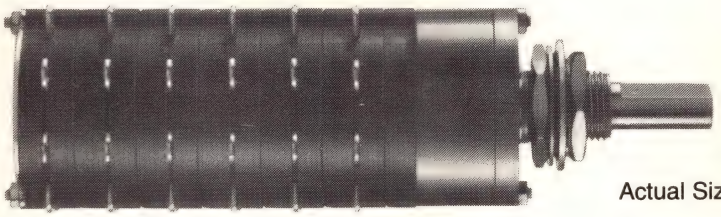
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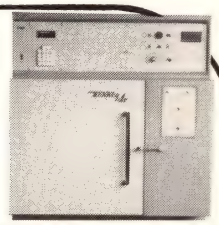
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BENCHTOP TEST CHAMBERS

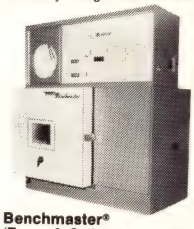
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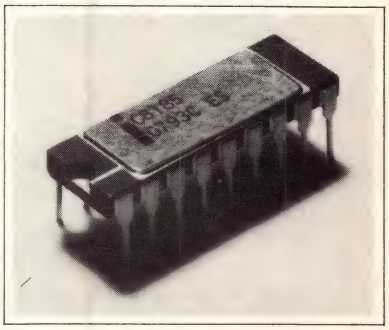
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New Products



8k 8085 RAM. Featuring address/data multiplexing directly compatible with the 8085A μP series, the 8185 1024×8-bit static RAM comes in an 18-pin DIP. The chip also includes two latched chip enables and an unlatched chip select in addition to separate read and write controls. Both chip enables control power-down by reducing maximum power consumption from 500 mW to 125 mW. Operating from a single +5V supply, a faster 8185-2 version matches the 5.0-MHz 8085A-2. Both 8185 and 8185-2 can be used to expand the memory of 8048, 8049, 8035 and 8748 μC systems. **Intel Corp,** 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-8080.

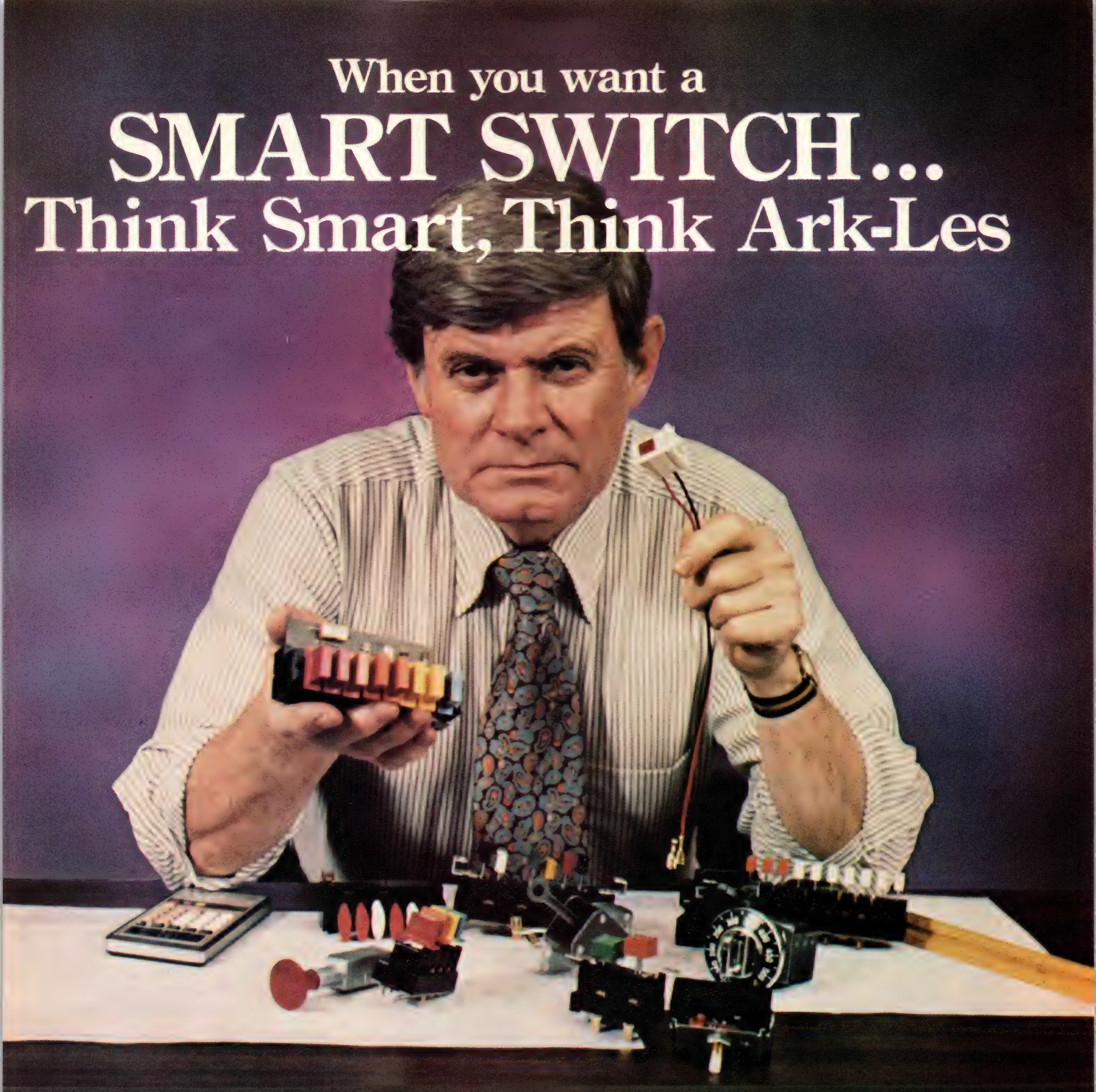
Circle No 198



SCHOTTKY PROMs. Organized as 1024×8 bits, Models SN74S478 and SN74S479 feature 45-nsec typical access time (70 nsec max), 40-nsec maximum enable time and typical power consumption of 630 mW. These chips also have multiple select lines, Ti/Ta fuse links, low-current pnp inputs and a choice of 3-state (S478) or open-collector (S479) outputs. Supplied in the standard 24-pin DIP configuration, the PROMs are plug compatible with the 74S474 and 74S475. From $19.35 (100). **Texas Instruments Inc,** Box 225012, MS 308, Dallas, TX 75265. Phone (713) 491-5115.

Circle No 199

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- **switches with built-in,solid-state circuitry that offer sophisticated control functions as well as the old ON-OFF.**

For a good many years, Ark-Les has supplied reliable, rugged, low-cost switches for automobiles, dishwashers, blenders, coffee machines, driers and scores of other quality products.

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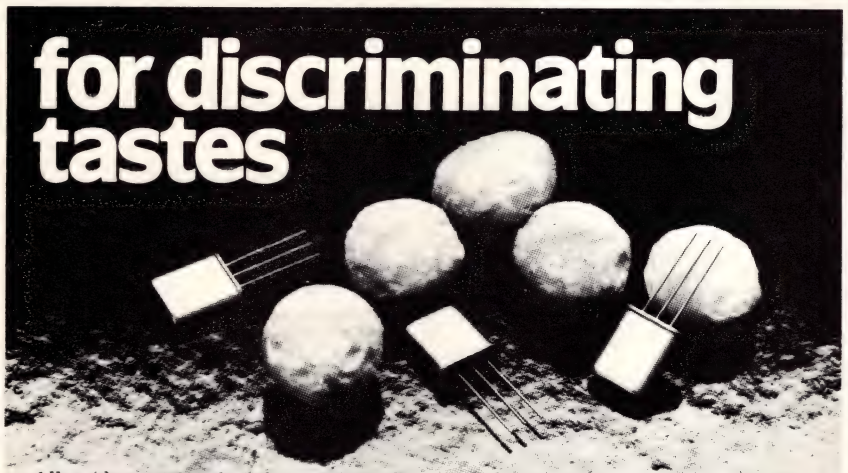
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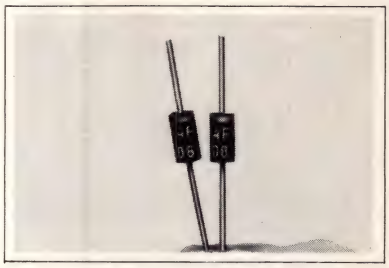
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New Products

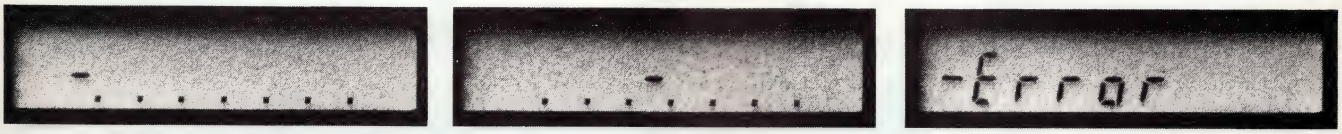


HIGH-CURRENT DIODES. Designed for applications requiring high power-handling and heat-dissipation capabilities, Model SKF4F4 diodes employ large axial leads (1.2 mm dia). These fast-recovery units have 450-nsec reverse-recovery times and maximum RMS forward currents of 7A. The line includes devices with peak reverse-voltage ratings from 200 to 1000V. $0.35 (100). Delivery, 4 to 6 wks ARO. **Semikron International Inc,** 11 Executive Dr, Box 83, Hudson, NH 03051. Phone (603) 883-8102.
Circle No 201

FAST μP. The AM2901B's improved operating speed is the result of shorter speed-critical data paths, made possible by a 25% reduction in manufacturing die size. Pin-compatible with the same manufacturer's 2901 and 2901A, the 2901B exhibits a minimum 123-nsec register-to-register add time for 16 bits of data. This spec includes the pipeline-register and carry-look-ahead delays along with the 2901 delays. The chip includes an 8-function ALU, a 2-port 16-word scratch-pad RAM, an accumulator and shift/control logic. From $9.95 (100). **Advanced Micro Devices Inc,** 901 Thompson Pl, Sunnyvale, CA 94086. Phone (408) 732-2400. **Circle No 202**

MICROWAVE TRANSISTORS. Designed for RF and IF usage to 5 GHz, Models HXTR-5103 and -5104 are npn bipolar devices. Both offer low thermal resistance, Ta_2N-ballasted resistors and dielectric scratch protection over their active areas. The HXTR-5102 has a guaranteed 1-dB compressed gain of 11 dB at 2 GHz with a typical P_{1dB} linear output power of 23 dBm at 2 GHz. Model HXTR-5104 provides a typical output power of 29 dBm at 2 GHz and can be used in amplifiers up to 4 GHz. HXTR-5103, $27.50; HXTR-5104, $43. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-4220.
Circle No 203

Whaddya' mean it's a handheld multimeter that...sorts, tweaks circuits, probes logic?



The Calcumeter's LIMITS Display Mode—unique "analog" readout from a $389 digital multimeter.

Revolutionary new Calcumeter® outperforms *any* 3½-digit DMM—without ac power—under $400!

Think of how you can save valuable time with the remarkable Calcumeter's LIMITS Display Mode: Simply key in high and low limits to the Calcumeter's memories, then push the LIMITS program key; thereafter every measurement you take in volts, amps or ohms automatically appears as a "floating" bar on the display, between the programmed limits. Below limits reads out "−Error," overlimits simply "Error."

For sorting you have 8 proportional segments formed by the display periods. When tweaking signal levels, you simply watch the limits bar approach the desired value. To probe logic you set 0.5V and 6V limits; the floating bar gives you zeroes and ones.

The Calcumeter's automatic warning beeper tone helps also, as it sounds off on "Error."

Limits display and measurement is just one of 6 special measurement modes on the Calcumeter, plus a myriad of manipulative advantages made possible by its Cmos microcomputer control. Basic features include:

3½-digit DMM—Autorange or fixed range; continuous or hold measurements (up to 1,000,000 single measurements from one 9-volt battery!); versatile display control enables you to shift into engineering notation, scientific notation or fixed decimal in 8 digits.

Specifications—Volts: 10 μV sensitivity through 1000 Vdc, 750 Vac; Ohms: 0.1Ω resolution through 20 MΩ; Amps: 10 μA resolution up to 200 mA (to 20 amps with accessory shunt). Basic accuracy: 0.25% dcV.

Special Measurement Modes:

Scaling and/or offset—Mx+b key programs constants to automatically scale or offset any measurement, or both. Automatically converts readings into meaningful engineering units of pressure, temperature, etc.

Digital averaging—Allows you to average n^{th} measurements and program away noise or increase resolution.

Decibel voltage—Display each measurement referenced to a programmed value in decibels. Display (dBV) = $20 \text{Log}_{10} \frac{\text{measurement}}{\text{stored value}}$.

And INVERSE conversion, PERCENT DEVIATION and HI-LO LIMITS.

Plus 11 special math keys: 2π, $1/x$, x^2, $\sqrt{x}$, $xy/(x+y)$, $xy/(x-y)$, 10^x, e^x, y^x, LOG, LN.

And the ability to store and move data to five different memory locations!

Data Logger Option operates off Data Port

Anyone desiring automatic data printout will want ESI's optional Data Logging Printer that plugs into the Calcumeter's data port. Sampling can be adjusted from 3 seconds to 3 hour intervals.

Other options include a temperature probe, RF probe, current shunt, battery eliminator, current probe and foot switch.



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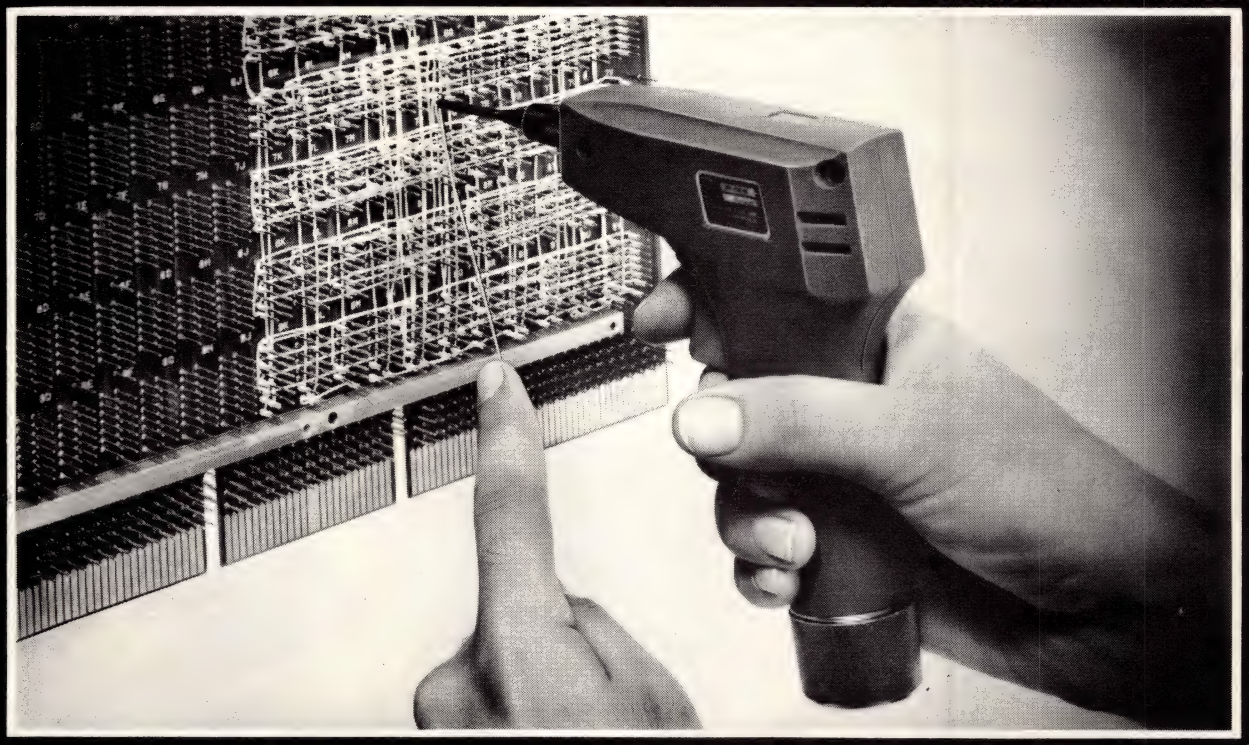
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"INDUSTRIAL" WIRE-WRAPPING TOOL

MODEL BW928

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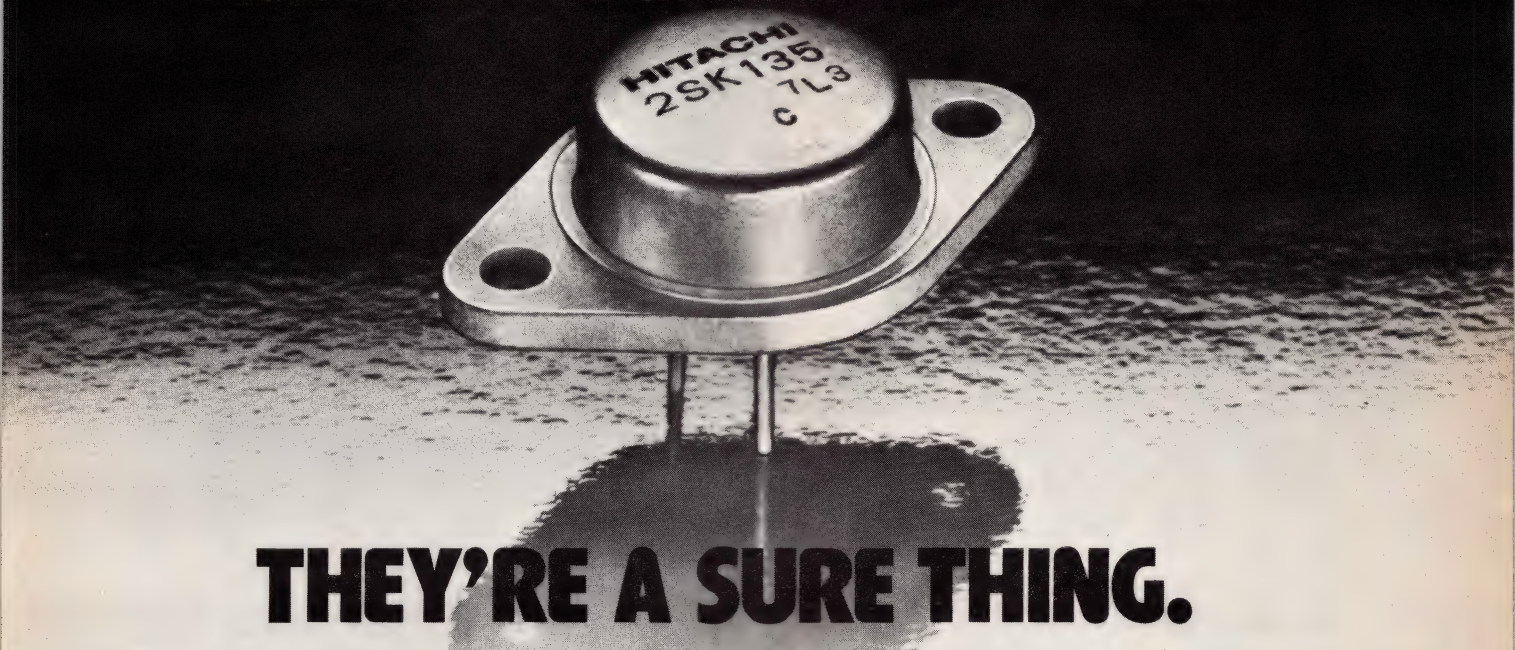
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  (2) Standard "C" Ni Cad Batteries (not included)
- **INTERCHANGEABLE BITS & SLEEVES**
  (not included)
- **REVERSIBLE ROTATION**
  For unwrapping, reverse batteries
- **BACKFORCE OPTIONAL**
  Model BW928-BF $52.95
- **POSITIVE INDEXING**
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*LEXAN™ GENERAL ELECTRIC

OK MACHINE & TOOL CORPORATION
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For more information, Circle No 21

COMPLEMENTARY HIGH-CURRENT, HIGH-VOLTAGE POWER MOS FETS ARE NO LONGER A DREAM.



THEY'RE A SURE THING.

Now you can have the first combination high-current, high-voltage complementary power MOS FETs! And you know what that means.

Many advantages over bipolar counterparts. Including superior high-frequency response and unusually fast-switching capability. These unique capabilities make them a prime choice for Class D and conventional linear amplifier applications. (A pair of Hitachi complementary power MOS FETs can deliver over 100 watts RMS into 8 ohms in audio applications.)

Plus excellent thermal stability and no secondary breakdown phenomenon.

And low RDS ON is ideal for switching regulator applications, too. Six Hitachi part numbers cover both N-channel and P-channel devices in a V_{DSX} and I_{DS} range from 120V to 160V at an I_{DS} of 7 amps.

Want more information? Write us on your company letterhead for further information. Or call (800) 323-6713.

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For more information, Circle No 107

Xylogics Technology Delivers an LSI-11® Cartridge Disk Controller.

Xylogics advanced state-of-the-art technology has done it again.

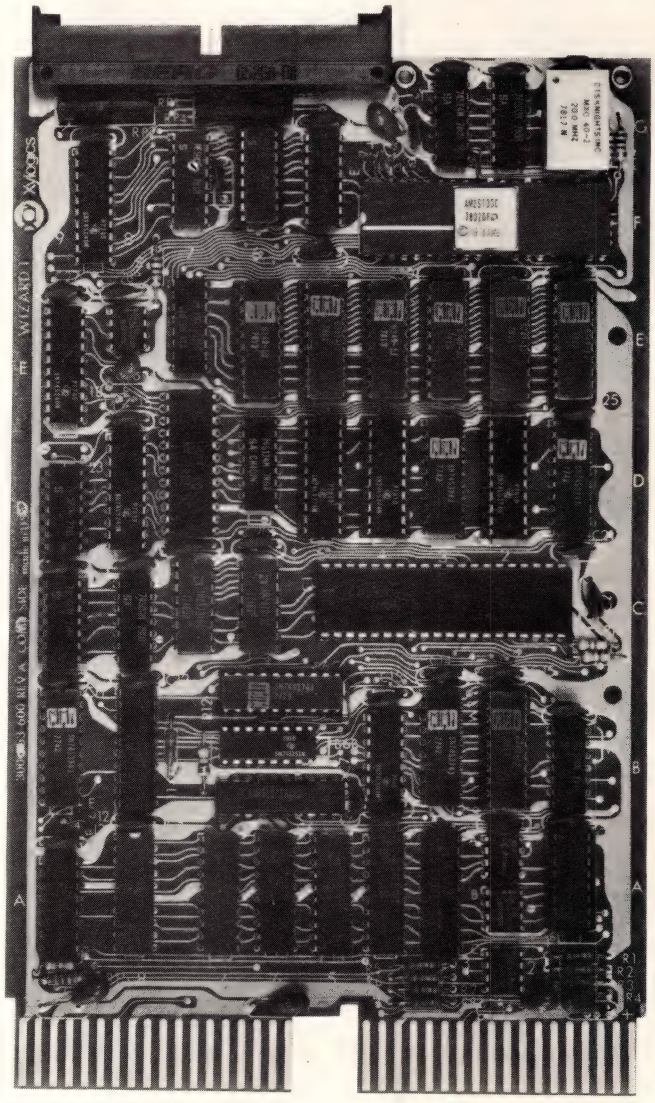
Now you can get the Model 510 Wizard, the only microprocessor based hard disk controller on a dual width board. This means fewer electronic components and best of all, superior controller performance in a cost-effective package.

The Model 510 Wizard provides the LSI-11 user with the on-line storage capacity flexibility of cartridge disk technology. Emulating the RKV11, the self-contained bootstrap permits direct start-up of RT-11 without need for a REV11 card. Subsystems using the Model 510 Wizard are available with 5MB, 10MB and 20MB cartridge disk drives.

Xylogics also offers complete LSI-11 based systems with software to meet most applications.

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Xylogics

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For more information, Circle No 108

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- D accuracy of ±0.0001
- C accuracy of ±0.02%

Measure L/Q, C/D, or C/ESR of

- Low-loss film and mica capacitors requiring improved D resolution and accuracy
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- Ceramic capacitors to MIL-C-39014C with 1-V rms test signal
- Dielectric materials

For

- Incoming inspection
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- Component design and evaluation
- Process monitoring
- Dielectric measurements

This is the GenRad Digibridge™ you've been waiting for. You'll find new features which will simplify capacitor, inductor and dielectric/material testing.

Now you can select any of 254 test frequencies from 240 Hz to 20 kHz directly on the keyboard. This new feature eliminates the requirement for variable frequency manual bridges or multiple fixed-frequency bridges. Studies of component value or dielectric constant versus frequency are simplified and fast.

Fast, accurate, automatic dielectric/material measurements with D resolution to 1 ppm eliminate those slow, manual bridge measurements. Autoranging removes the guesswork from selecting the best measurement range.

For even more precision, automatic zeroing compensates for stray C and G at the text fixture, handler or test cell by a simple keyboard operation. Automatic self-check/diagnostics on power-up provide an in-depth check of the internal electronics and calibration.

You can select the Δ% mode to monitor the change of a component's or material's value versus a nominal value or initial measurement under stress. Or, you may want to use the ten automatic limit-comparison bins for sorting into tolerance categories. You'll like the single bin number display for faster operator test rates.

Some other important features that make the GR 1688 attractive are keyboard lock, selectable voltage levels of 0.25 V and 1.0 V, four selectable test speeds to 130 ms, a built-in Kelvin test fixture, and an IEEE-488 bus/handler option. And there's a lot more.

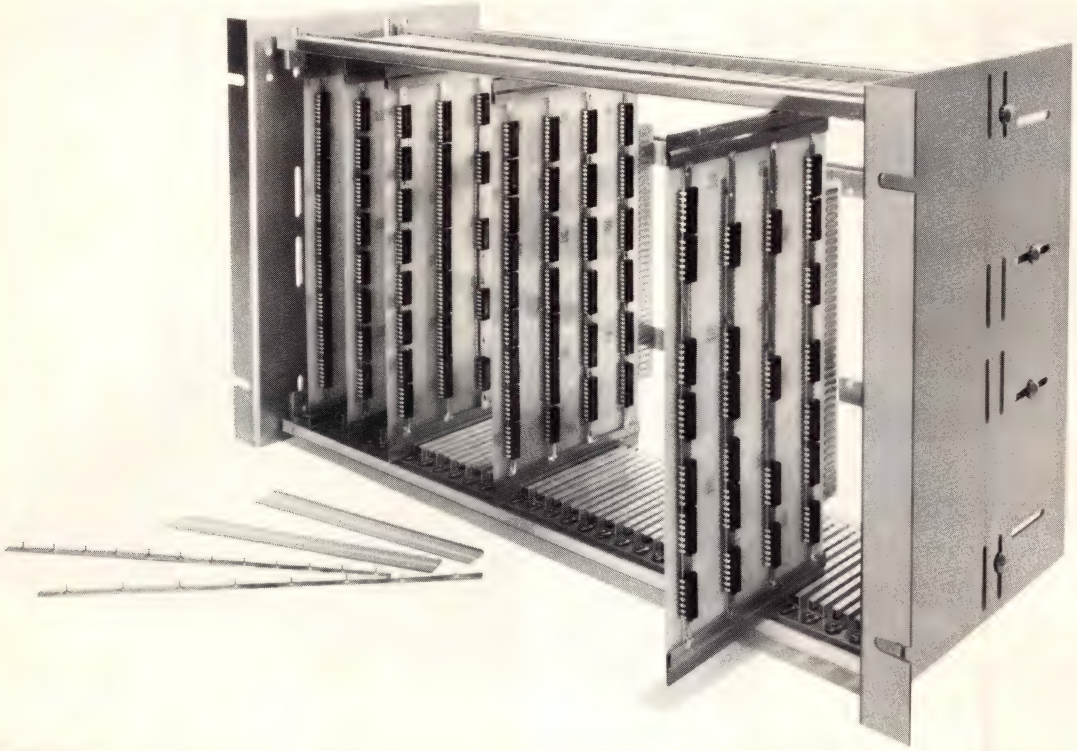
Make a breakthrough in your testing with the new GR 1688 Digibridge. Call your GenRad sales office.

For more information, Circle No 109

GenRad

300 BAKER AVENUE, CONCORD, MASSACHUSETTS 01742 • ATLANTA 404 394-5380 • BOSTON 617 646-0550 • CHICAGO 312 884-6900 • DALLAS 214 234-3357 • DAYTON 513 294-1500 • LOS ANGELES 714 540-9830 • NEW YORK (NY) 212 964-2722, (NJ) 201 791-8990 • SAN FRANCISCO 408 985-0662 • WASHINGTON, DC 301 948-7071 • TORONTO 416 252-3395 • BOURNE END (UK) (06285) 2 66 11

Why IERC's new heat dissipation system for .300" DIPs is more efficient, simpler and costs less than alternate technologies.



The IERC system provides significant thermal transfer for better thermal balance as well as an efficient thermal interface from DIPs to card holder.

The Problem

The thermal management of large numbers of dual-inline packages on a single PC board can be a problem, particularly in telecommunications and logic networks. Single DIPs rarely dissipate as much as one watt, but a board full of them can add up to 15-25 watts. IERC's system of conduction bars and side rails provides a simple, inexpensive, off-the-shelf solution to the problem.

Some Expensive Solutions

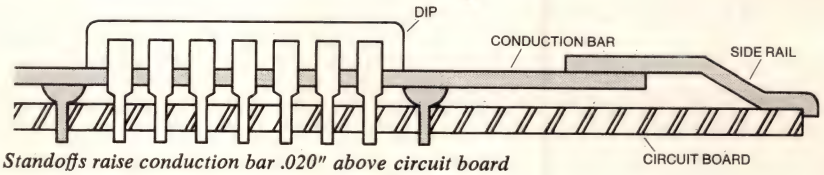
Ladder networks will do the job. Of course there is the cost of fabrication, and the difficulty of epoxying the networks to the boards, which makes assembly and repairs a nightmare.

Another approach is to plate heat-dissipation strips directly onto the board. A good idea for some applications, except the cross-sectional dimensions of plated strips (and hence their dissipating efficiency) is limited by the plating process. Also, plated strips require valuable board space and often introduce capacitance and induction problems into your design.

Boards with heat-dissipating metal cores require extremely careful engineering, and are costly and very difficult to make.

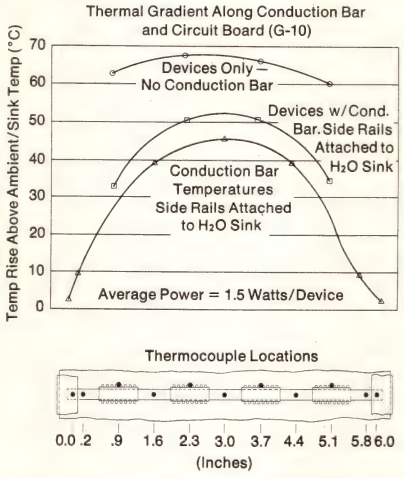
IERC's Better Solution

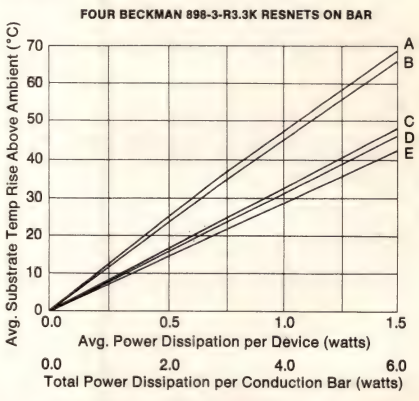
IERC's heat dissipation system consists of conduction bars and side rails, both of which are made from high-thermal-conductivity copper (solder plated) and are available in practically any length. The conduction bars can be wave-soldered into place along with other board components. The IERC system permits quick fabrication of a custom heat-dissipating network for .300" DIP systems, with no restrictions on the distance between DIPs or rows of DIPs. Call or write today for more information.



Standoffs raise conduction bar .020" above circuit board to accommodate metal traces between the standoffs, and to permit removal of solder residue.

IERC's conduction bar system lowers substrate temperatures 30% — 40%.





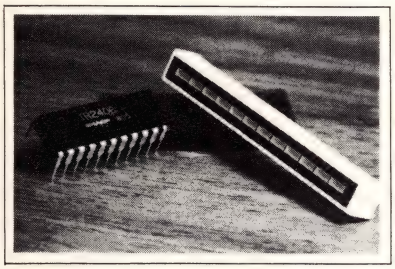
A — Device only, natural convection, horizontal board;
B — Device only, natural convection, vertical board;
C — Device with conduction bar, natural convection, horizontal board;
D — Device with conduction bar, natural convection, vertical board;
E — Device with conduction bar, side rails attached to infinite heat sink.

IERC

International Electronic Research Corporation, 135 West Magnolia Boulevard, Burbank, California 91502 (213) 849-2481

For more information, Circle No 110

New Products



BAR-GRAPH PARTS. A 12-level LED level detector and driver, the IR2406 IC successively lights each diode in steps equal to $V_{ref(max)}-V_{ref(min)}/13$. Input and both reference voltages can range up to the maximum supply voltage of 18V. Suited for use with the driver, the GL 112R3 12-step LED array contains three groups of four series-connected LEDs. With a typical forward-voltage drop of 1.85V at 5 mA, each diode outputs 0.30 mcd at 695 nm. The IR2406 in a 22-pin DIP and GL 112R3 are each $4.50 (100). **Energy Electronic Products Corp,** 6060 Manchester Ave, Los Angeles, CA 90045. Phone (213) 670-7880. **Circle No 204**

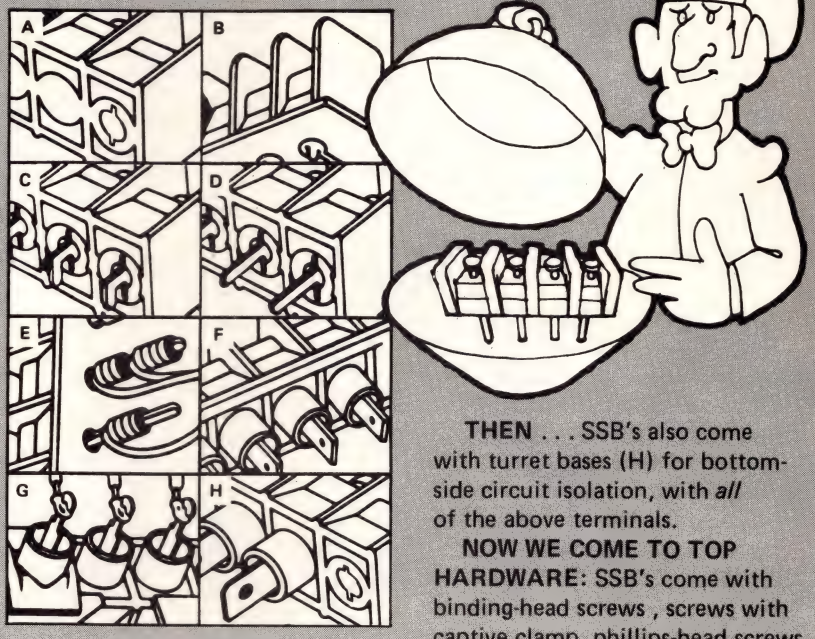
OPTOCOUPLERS. Offering a 100% transfer ratio (at I_F=10 mA, V_{CE}=10V), 4N35/36/37-Series high-efficiency devices have UL recognition. They also feature high electrical isolation (min V_{ISO}=7500V peak) and low collector-emitter saturation voltage ($V_{CE(sat)}$= 0.3V dc max at I_F=10 mA, I_C=0.5 mA). Packaged in 6-pin DIPs, the units suit applications requiring electrical isolation, high current-transfer ratio, small package and low cost. $1.20 (100). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-4556.

Circle No 205

4k STATIC RAM. A 4096×1-bit RAM using N-channel MOS technology, the Am9044 offers access times as fast as 200 nsec. A companion device, the Am9244, has a chip-select and power-down feature that reduces power consumption by about 50% from the rated 368 mW. Both chips operate from a +5V supply with TTL-compatible interface levels and are available in 18-pin plastic or ceramic DIPs. From $9.65 (100). **Advanced Micro Devices Inc,** 901 Thompson Pl, Sunnyvale, CA 94085. Phone (408) 732-2400.

Circle No 206

BARRIER BLOCKS À LA CARTE



The "menu" of BUCHANAN® Single-Screw Barrier Blocks offers a recipe for every taste. In automated or manual installation, mounted on PC board, panel, or chassis, BUCHANAN SSB's are the most cost-efficient blocks on the market. And you can order them cooked up in almost every style and combination. Here are a few choice selections . . .

SSB's come *without* bottom terminals (A), for surface-mounting anywhere . . . *with* terminal pins for PC Board soldering: straight (B), or bent for perpendicular mounting (C) . . . with wire-wrap pins, for use with automated or manual wire-wrapping tools (D); also compatible with AMP® Crimp-Clip Termi-Point connectors (E) . . . with standard quick-connect terminals (F), excellent for interfacing machine wiring harnesses with field-installed wiring . . . and with solder-tail terminals (G), too.

THEN . . . SSB's also come with turret bases (H) for bottom-side circuit isolation, with *all* of the above terminals.

NOW WE COME TO TOP HARDWARE: SSB's come with binding-head screws , screws with captive clamp, phillips-head screws, or with a choice of 7 different quick-connects, or two styles of solder tabs.

WAIT . . . THERE'S MORE: You can select either 3/8" or 7/16" contact spacings . . . 1 to 32 terminals per block . . . choose from five different colors . . . six variations of hot-stamped circuit identification numbers . . . AND, you can get the exact combination you need — standard or special — at any Authorized BUCHANAN Distributor with a PDQ (Precise Designs Quickly) Center.

Want *more* details? The Reader Service Card will get you a complete BUCHANAN SSB brochure.
Bon Appétit!



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Atlanta, GA, (404) 261-1224.

For more information, Circle No 111



Your lights Vs. Our LED Lites.



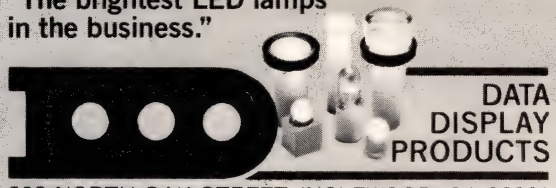
You could be making a glaring mistake if you're not using Brite-Lites. The LED lamps that really are 25x (50 mcd vs. 2 mcd) or brighter and more reliable than all the rest. They leave other LEDs in the shadows. Brite-Lites are tested and proven winners time after time in application after application.

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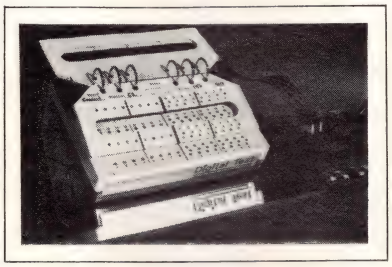
For more information, Circle No 112

New Products

INSTRUMENTATION & POWER SOURCES



TEMPERATURE PROBE. Used with digital or analog voltmeters, Model TP-28 generates 10 mV/°C or °F, settles in 10 sec (liquid immersion) and provides readings accurate to within 1.7°C plus meter error. A switch lets you select ranges of −50 to +150°C or −58 to +302°F, and the probe operates for over 120 hours on a 9V transistor-radio battery (a low-battery indicator circuit is included). $75. **B&K-Precision,** 6460 W Cortland St, Chicago, IL 60635. Phone (312) 889-9087. **Circle No 207**



LOGIC-BOARD TESTER. To use the Digilyzer, the operator visually compares the panel LEDs' pattern with flip cards showing the correct pattern for each IC. For each pin, the LEDs indicate not only its logic level, but if the pin is shorted to ground (or a voltage below ground), shorted to the positive supply (or a voltage above), or invalid. You can easily interpret discrepancies from the correct pattern to be a broken trace; a trace shorted to a power supply, ground, or another signal trace; or a faulty, wrong-value, missing, or otherwise incorrect component. $495. **Digital Test Inc,** 16 Lakeside Office Park, Wakefield, MA 01880. Phone (617) 245-8200. **Circle No 208**

STRIP-CHART RECORDERS. Offered in 1-pen or 2-pen versions and with 2-, 3-, 6- or 12-point dot-printing capabilities, the Model ER-180 7-in. recorder provides full-span accuracy of ±0.3% and full-span response of 1 sec max. Each 11-3/8×11-3/8-in. version features high normal-mode and common-mode rejection, along with full-span sensitivity of 3 mV. Options include multi-range recording, electronic control of up to 24 individual alarm settings, retransmitting slide wires and an air-purge connection. **Yokogawa Corp of America,** 5 Westchester Plaza, Elmsford, NY 10523. Phone (914) 592-6767. **Circle No 209**

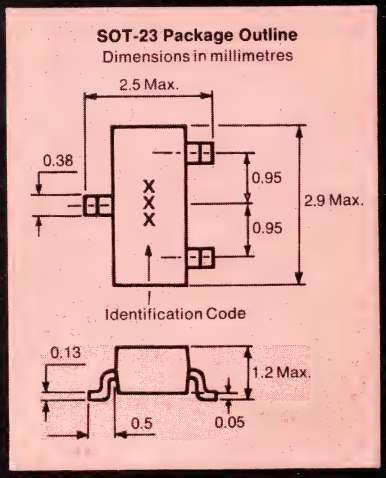
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■ Reduced assembly costs ■ Increased production rate ■ Lower inventory cost ■ More reliable connections ■ Semiconductor rework without degrading electrical performance ■ Individually branded parts ■ Mechanically rugged

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SOT-23 package shown magnified 4X



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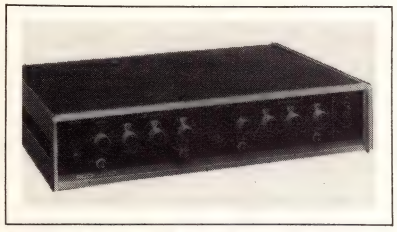
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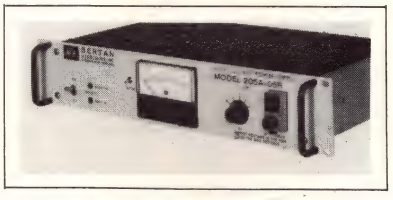
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MODULATION ANALYZER. Combining the capabilities of a modulation meter, frequency counter and power meter, Model 8901A accurately characterizes all types of AM, FM and phase-modulated signals in the 150-kHz to 1300-MHz range. You can use this μP-based instrument in a fully-automatic system, manually or in combination. The unit is programmable through the HP-IB/IEEE 488-1975 interface bus. $7500. **Hewlett-Packard Co.** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-1501.
Circle No 210



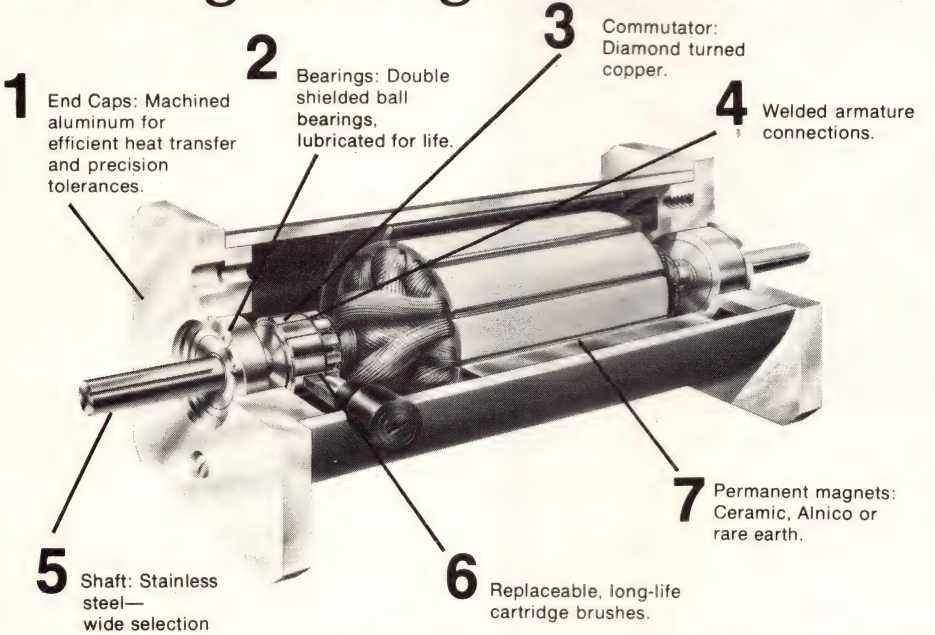
PROGRAMMABLE FILTER. Independent dual 115-dB/octave, 0- to 110-kHz low-pass filter sections in Model 752 prevent the aliasing of out-of-band components into the frequency band of interest. Cascading channels allows you to achieve a 230-dB/octave slope. This spec, passband ripple of ±0.25 dB and stopband attenuation of 80 dB provide "brick-wall" results. You can program cutoff frequency, as well as gain and channel selection, by front-panel controls—or remotely through a parallel-input, buffered interface. **Rockland Systems Corp,** Rockleigh Industrial Park, Rockleigh, NJ, 07647. Phone (201) 767-7900.
Circle No 211



HV LAB SUPPLIES. All of the solid-state Series 205A/210 units are arc protected, short-circuit proof and self restoring. You can order models with outputs ranging from 0 to 1 kV to 0 to 50 kV and power levels of 30W for Series 205A, 225W for Series 210. Specs show 0.001% regulation and ripple, and a TC of 50 ppm/°C. Standard features include digital voltage controls, panel voltage and current metering, remote voltage and resistance programming and reversible polarity. From $550. **Bertan Associates Inc,** 3 Aerial Way, Syosset, NY 11791. Phone (516) 433-3110.
Circle No 212

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Circle No 213

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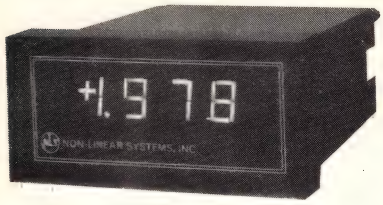
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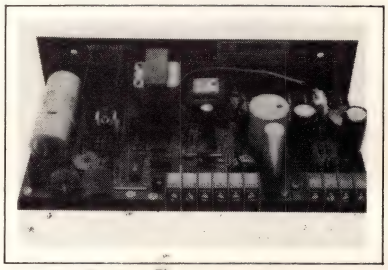
RM-350, circle no 115
RM-351, circle no 116

New Products

DIGITAL THERMOMETER. The Handi Temp provides features such as direct switching from °C to °F and the acceptance of surface, needle or other probe designs that plug into the unit using compensated miniature connectors. Both Type J and K units are offered, furnishing 0.5% reading accuracy (1°F). $255 for Type J (Model DH11) or K (Model DH12) units—complete with NiCd batteries, case, battery charger and general-purpose probe. **Barber-Colman Co,** 1700 Rock St, Rockford, IL 61101. Phone (815) 877-0241. **Circle No 214**

TEMP CONTROLLERS. Four portable models in the 700 Series furnish proportional temperature control for electrical resistive heating. Each unit consists of a solid-state controller and comes in a control cabinet that contains an ON/OFF switch, power-level indicator, load-output socket (115V or 230V), sensor jack, set-point knob and scale, line fuse and an 8-ft line cord. Models 700 and 720 provide 0 to 100 reference scale dials; Models 710 and 760 are direct reading (°C and °F dial); Model 760 has a direct-reading meter. $270 to $435. **RFL Industries Inc,** Boonton, NJ 07005. Phone (201) 334-3100. **Circle No 215**

OSCILLOSCOPE/DMM. Claimed to be the first to contain both a 5-MHz, 5-mV dual-trace scope and a full-function DMM in a 10-lb package that measures 4.4×9.3×14.2 in., Model 305 operates for 5 hrs on its built-in battery pack. Vertical modes include CH1, CH2, Chop, Alt, Add and Invert CH; sweep speeds run from 1 μsec to 50 msec/div (plus a 10× magnifier). $1725. **Tektronix Inc,** Box 500, Beaverton, OR 97077. Phone (800) 547-1572. **Circle No 216**

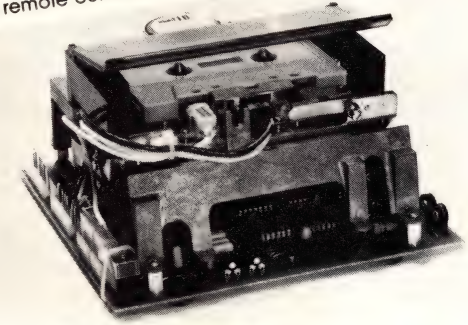


OPEN-FRAME SWITCHERS. All versions of the 1-output Model LR7500, 3-output Model LR7700, and 4-output Model LR7800 deliver 75W out, mount on 2 surfaces and can be ordered with OVP on the main output. The 4.87×2.1×7-in. Model 7500 provides 12V/6.5A or 15V/5A. Two inches longer, Model 7700 adds two 12W auxiliary outputs to the 7500's main output. $99 (100) for LR7500; $126 for LR7700. **California DC,** 31117 Via Colinas, Bldg 402, Westlake Village, CA 91361. Phone (213) 991-1168. **Circle No 217**

SPECTRUM ANALYZER. The μP-controlled Model 8566A spectrum analyzer furnishes 10-Hz resolution accompanied by sensitivity of −137 dBm up to 1 GHz, −134 dBm to 5.8 GHz and −115 dBm at 22 GHz. Related characteristics are a 80-dB dynamic range and ±2.2-dB amplitude flatness. You can directly measure (on microwave signals) line-related sidebands 50 dB down. $47,500. Delivery, 18 wks ARO. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-4234. **Circle No 218**

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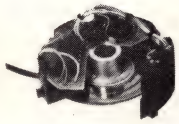
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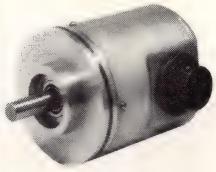
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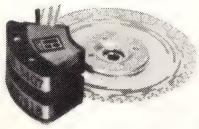
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OPTICAL
INCREMENTAL FOR MOUNTING TO MOTORS
1.5 IN. DIAMETER



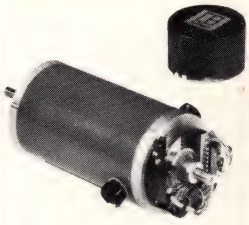
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Litton **ENCODER DIVISION**

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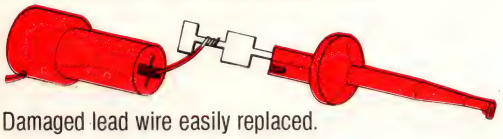
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The XM Micro Hook is designed for difficult IC test connections. Light weight (less than 1 gram) and Finger-eze Hypo Action permit direct hookup to delicate wires where weight and leverage may damage component. Fully insulated to a single contact point for true readings.

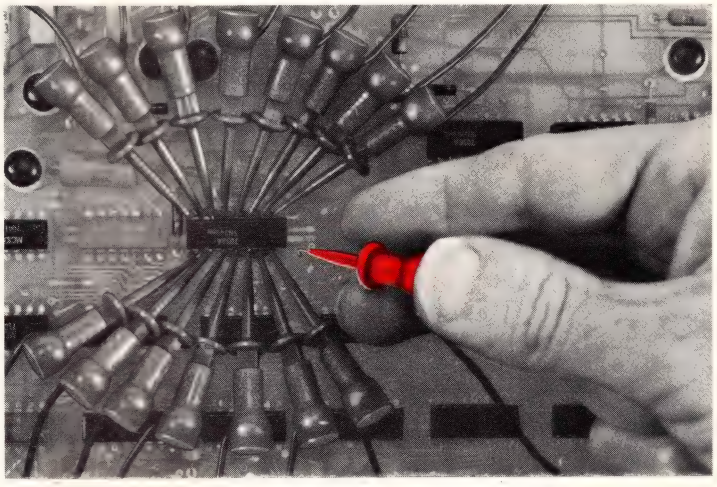
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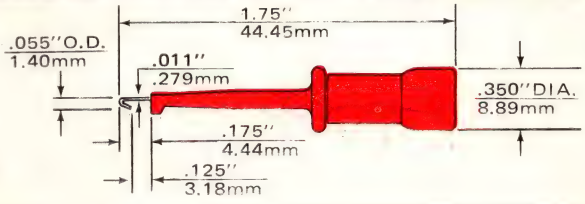
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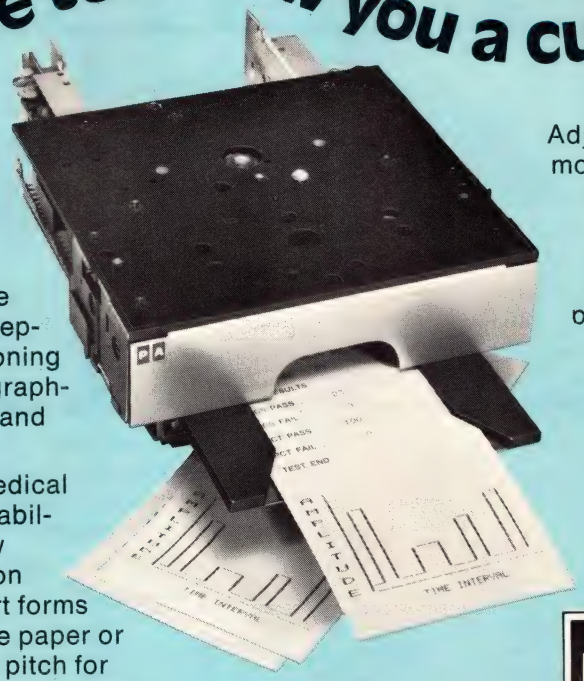
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All it took was combining our long-life 5 x 7 dot matrix needle head with a stepping motor that controls ticket positioning until the message (alphanumeric or graphics) is complete. Result: both analog and digital data, on the same card.

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PA PRACTICAL AUTOMATION INC.

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PR-5 PRESET COUNTER

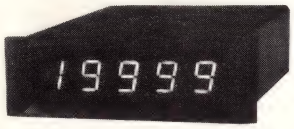


Unit Quantity—$164

Features Include:

- Five-digit LED display of count plus 5-digit preset.
- Counts at 500 kHz pulse and 300 Hz contact closure.
- Small: 2.25" Hx3.25" Wx4.0" D; fits in the palm of your hand.
- Permits multiple presets.
- Optional battery pack for standby operation.
- Solid-state LSI circuitry with high noise immunity.

PC-4 EVENT COUNTER



Unit Quantity— $60

Features Include:

- Counts to 19999 events @ up to 200 kHz.
- Programmable decimal.
- TTL or switch input.
- Electronic reset.
- Display inhibit/dimming and lamp test.
- Leading zero suppression capability.
- Multiplexed BCD output.
- Multiple units may be cascaded.
- Large 0.3" LED display.
- Small size: 1" Hx2.5" Wx3.25" D.
- Operates from +5 vdc supply; using less than 0.75 watts.
- Optional 115 vac operation.

Non-Linear Systems, Inc.
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PC-4, Circle No 138
PR-5, Circle No 139



The Intecolor 8080 Development System Gives You Total In-House Control. You probably already realize that an in-house development system would give you a lot more control, flexibility and efficiency.

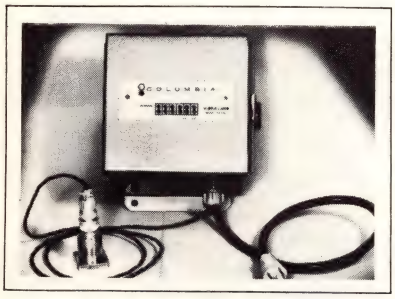
You may not realize that now you can afford one. Our new low-cost 8080 development system features a 19-inch, 8-color data entry terminal with an Intel 8080 micro computer. A 110 CPS bi-directional desk top printer. A dual mini disk drive and our 2708/2716 PROM programmer. It also includes a sophisticated ROM-based Text Editor and Assembler. And as an option, a FORTRAN compiler with double precision by Microsoft©

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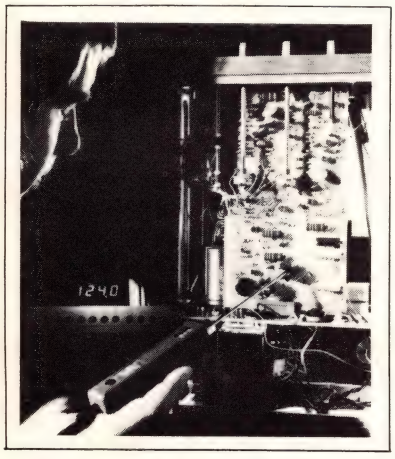
For more information, Circle No 123

New Products



VIBRATION DETECTORS. Reacting in milliseconds, CV-200-Series units can measure excessive moving-equipment vibration, output an automatic warning and shut down the machinery before a serious failure can occur. The detectors furnish an electrical signal precisely proportional to the vibration—a signal that can be filtered, rectified, compared, regulated, selected, rejected or operated on by a computer before the controlling action is taken. Frequency response spans 2 to 500 Hz, temperature range covers −40 to +170°F and repeatability equals 1% of setting. Power can be 115V, 60 Hz or 28V dc. **Columbia Research Laboratories,** MacDade Blvd & Bullens Lane, Woodlyn, PA 19094. Phone (215) 532-9464.

Circle No 219



DMM TEMP PROBE. Used with a 10-MΩ-input DMM that has a 200-mV range, this probe lets you make surface and immersion measurements between −20 and +125°C. Response time equals 4.5 sec, while accuracy specs at ±1.5% and 2°C and a probe output of 1 mV/°C permits direct temperature reading in °C. The probe grip houses the thermistor sensor, amplifier circuit and battery. **Siemens Corp,** 186 Wood Ave South, Iselin, NJ 08830. Phone (201) 494-1000.

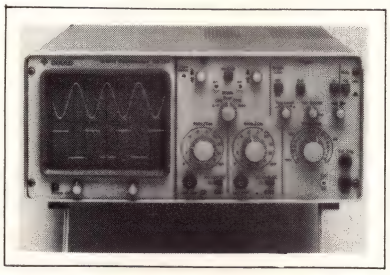
Circle No 220

LINE-VOLTAGE RECORDERS. Both the Model LVA-110-R and LVA-110-RX provide a permanent record of line-voltage disturbances such as sags, surges and drop-outs and the exact time of occurrence. A high-speed ac V/F converter enables the units to monitor the line voltage with 1/2-, 1- or 2-cycle time bases. Device memories are continuously updated with the worst-case highest and lowest rms voltages. The multiplexing of these memories at 1-1/2-min intervals allows the stored data to be transferred to recorder memory, then outputted for chart recording. $1265. **Power-Science Inc,** 7571 Convoy Ct, San Diego, CA 92111. Phone (714) 292-4322.

Circle No 221

RECORDER. Offering a choice of fine-line-thermal or pressurized-fluid writing, Model 2100 achieves a response of dc to 30 Hz FS at 50 mm (dc to 80 Hz at 10 mm), with <8 msec rise time and <1% overshoot. The device accepts any 4600 Series plug-in amplifier and is electrically compatible with all other Gould amplifiers and signal conditioners. $1495. Delivery, 45 days ARO. **Gould Inc,** Instruments Div, 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315.

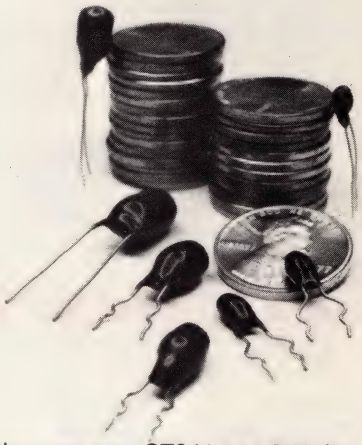
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DUAL-TRACE OSCILLOSCOPE. The 12-MHz Model OS253 sports dual-trace and X-Y display capability; an 8×10-cm CRT; 2-mV/cm vertical sensitivity with ac, ground and dc coupling and channel sum and difference with channel 2 inversion. The unit also provides bright-line operation, dc coupled Z-modulation input, calibrator output and a trace-rotate control. You get continuously-variable horizontal sweep rates from 500 nsec/cm to 0.2 sec/cm (in 18 ranges); triggering is ac coupled. The 5-1/2×12×18-in. instrument carries a 2-yr warranty. $695. **Gould Inc,** 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315. **Circle No 223**

SIEMENS

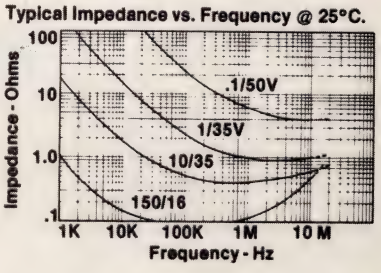
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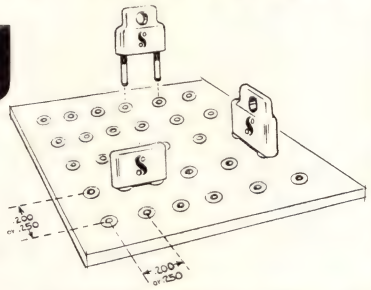
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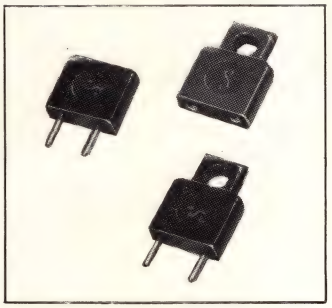
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PROGRAMMABLE CONNECTIONS

Sealectro molded Shorting Plugs & Jacks



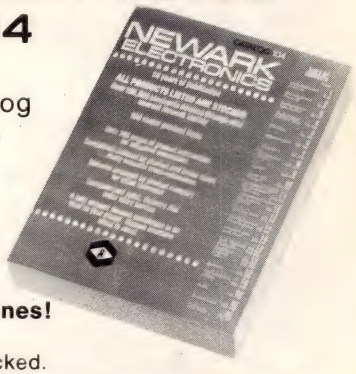
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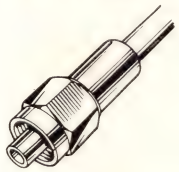
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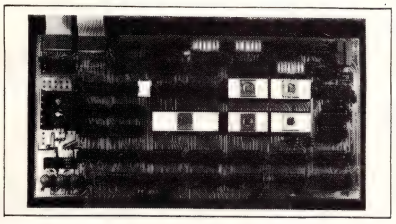
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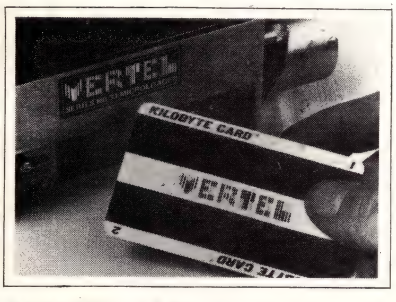
For more information. Circle No 127

New Products

COMPUTER-SYSTEM SUBASSEMBLIES

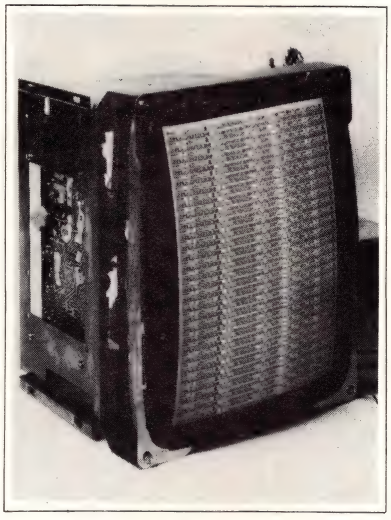


μP SYSTEM. Allowing two 2650 μPs to operate with interleaved fetch-execute cycles, the Slavemaster 2650 fully utilizes all available S-100-bus time. This 2-board system maintains precise processor timing and, once synchronized, requires no processor interaction. You can let the μPs share all system memory or enable each μP to access only 1k of the other's memory. $269 for master, $259 for slave. **Victoria Micro Digital,** 401 Dundee St, Victoria, TX 77901. Phone (512) 575-3836. **Circle No 241**



MAGNETIC CARD. The credit-card-sized Kilobyte Card stores up to 256 8-bit bytes on each of its four magnetic stripes. Compatible with the manufacturer's KB-31 Microloader and LC-31 Gameloader reader-encoders, the card suits applications such as automatic test and measurement equipment, machine-tool controls, intelligent terminals and process-control systems. $1.25. Delivery, 60 to 90 days. **Vertel Inc,** 125 Ellsworth St, Clifton, NJ 07012. Phone (201) 472-1331. **Circle No 242**

GRAPHICS IMAGING SYSTEM. The RGB-256 features 256×256-dot resolution with four bit planes and includes American (NTSC) and European (PAL) color- and grey-scale encoders that provide up to 16 colors or shades. The 1-card unit drives standard color or black-and-white TV monitors directly through a single 75Ω cable. An on-board phase lock loop permits synchronization with an external video source, such as a TV camera. $1295 (100). **Matrox Electronic Systems LTD,** 2795 Bates Rd, Montreal, Que H3S 1B5, Canada. Phone (514) 481-6838. **Circle No 243**



HIGH-DENSITY CRT MONITOR. Operating at 50,000 scan lines/sec, the VR-800 produces image resolution three times that of ordinary CRT monitors, and tripled data density as well. The unit displays 800 noninterlaced scan lines—equivalent to 66 lines of 7×9 characters—and refreshes at 60 Hz. $375 (1000). **Moniterm Corp,** Box 262, Long Lake, MN 55356. **Circle No 244**

I/O CARD WITH MODEM. The S-100-bus-compatible 8P2SM offers eight bidirectional parallel ports, two serial inputs and two serial outputs. You can configure one set of serial ports for RS-232 operation and the other as a full-duplex, answer-or-originate modem. The parallel interface operates over two edge connectors, and a 16-pin DIP socket provides serial-interface connections. $199 ($149 kit). **MicroDaSys,** Box 36051, Los Angeles, CA, 90036. Phone (213) 935-4555. **Circle No 245**

JOB SHOPPING?

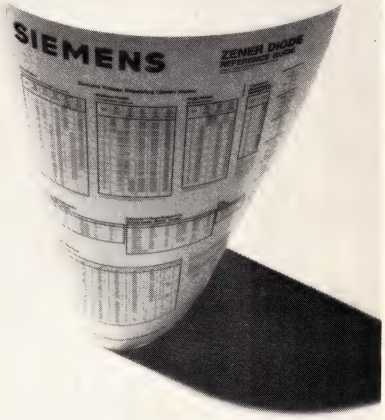
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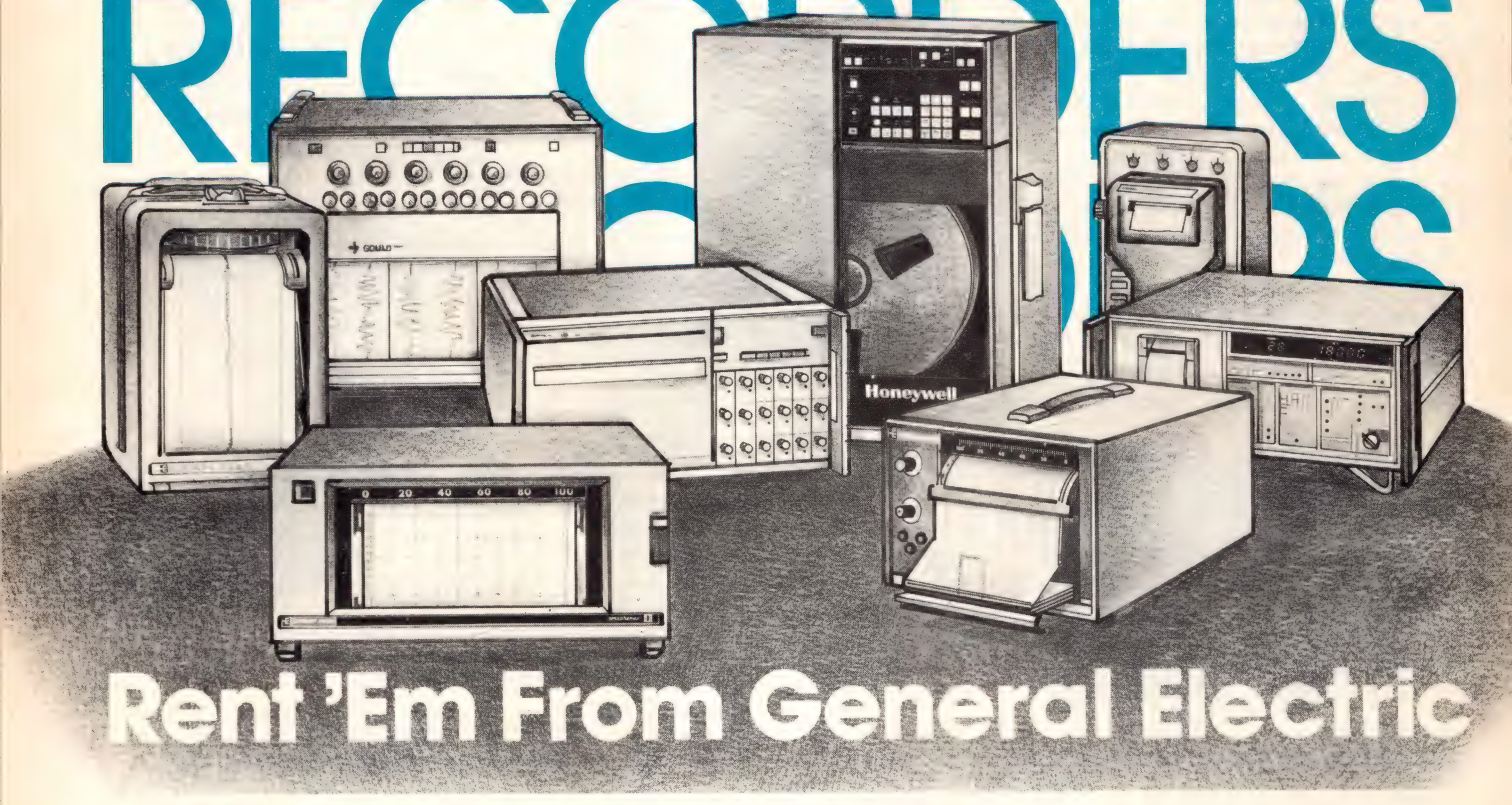
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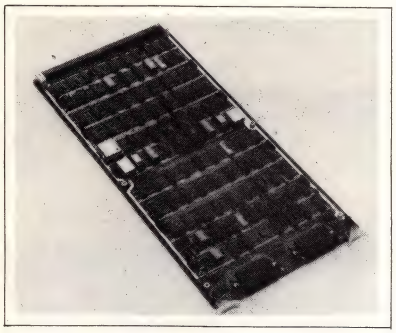
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GENERAL ELECTRIC

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New Products

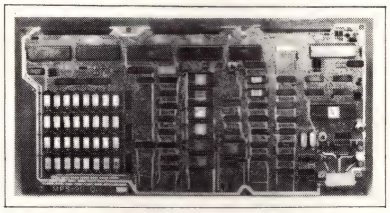


SINGLE-LINE ADAPTER. This programmable asynchronous single-line adapter (PASLA) provides a 2-channel interface between an Interdata multiplexer or selector-channel I/O bus and any asynchronous data set or local terminal with an RS-232C interface. Each dual PASLA channel offers an independent switch-selectable device address, high or low baud selection, half-duplex or full-duplex mode and modem-input signal assertion. $695. **MDB Systems Inc,** 1995 N Batavia St, Orange, CA 92665. Phone (714) 998-6900. **Circle No 246**

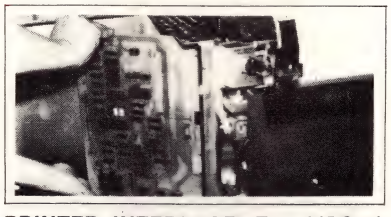
I/O BOARD. Designed for rugged industrial environments, the dual-height DT2768-I isolated digital I/O board offers hardware and software compatibility with DEC's DRV11 parallel-line interface unit for its LSI-11 and LSI-11/2 μCs. The board contains a 16-bit wide data-input register, a 16-bit wide output register and a control/status register, and features 200V bit-to-bit isolation for all lines that interface with external processes. $395 for the DT2768-I, $195 for the DT2768 non-isolated version. **Data Translation Inc,** 4 Strathmore Rd, Natick, MA 01760. Phone (617) 275-2846. **Circle No 247**

ADD-ON MEMORIES. Hardware and software compatible with IBM 303X computers, the ARM-303X Series provides up to 256k bytes of memory per board. The ARM-3031 and -3032 offer four-way interleaving, while the -3033 has eight-way interleaving. Memory space expands in 1M-byte increments to a maximum of 16M bytes in one cabinet. You can also use the boards as self-contained units and install them on hinges in place of a computer-cabinet door. $50,000 per megabyte. **Ampex Corp,** 200 N Nash St, El Segundo, CA 90245. Phone (213) 640-0150. **Circle No 248**

DACs FOR MICRONOVA. Units in the ST-MNOVA-DA Series of DAC boards slide directly into MicroNova card slots. These boards feature 4-μsec settling time to within ± 1/2 LSB of final value, four jumper-selectable output voltage ranges and 50 mΩ output impedance. A 4-channel version offers an optional ±15V, 150 mA dc/dc power converter. $630 for 4-channel DAC with dc/dc converter; $550 without converter; $785 for 8-channel DAC. **Datel Systems Inc,** 1020 Turnpike St, Canton, MA 02021. Phone (617) 828-8000. **Circle No 249**



μC WITH DISC CONTROLLER. The Z80-based, 90F/MPS board computer includes up to 64k bytes of dynamic RAM, up to 14k bytes of EPROM with programmer, 1k byte of static RAM, up to four 8-bit programmable I/O ports, four programmable counter-timer channels, an RS-232C or 20-mA serial port and a PROM-resident system monitor with debug capabilities. The on-board floppy-disc controller supports up to four 5-1/4 or 8-in. single- or double-density drives. $1295. **Quay Corp,** Box 386, Freehold, NJ 07728. Phone (201) 681-8700. **Circle No 250**



PRINTER INTERFACE. The MPC-15 interfaces Dataproducts 2230, 2260 and 2290 high-speed printers with complex-protocol communication lines. A printer can access the board's 128-character memory at speeds up to 500 kHz through a TTL-compatible port. The MPC-15 board plugs directly into the printers but stand-alone operation is also available, as well as firmware packages for most line protocols. $915 (100) with 1k memory. **Air Land Systems Corp,** 2820 Dorr Ave, Fairfax, VA 22031. Phone (703) 573-1100. **Circle No 251**

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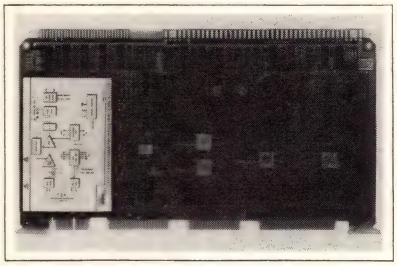
- Much smaller than comparable DC chokes
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- DC current capability to 1¼ amps
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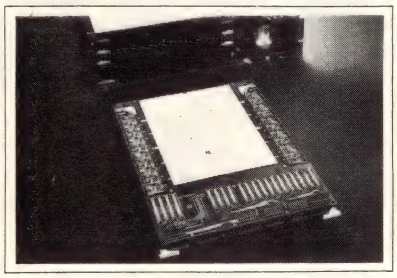
Siemens Corporation
Components Group
186 Wood Avenue South
Iselin, New Jersey 08830

For more information, Circle No 130

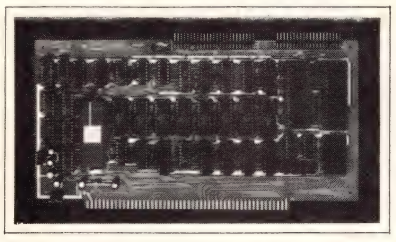
New Products



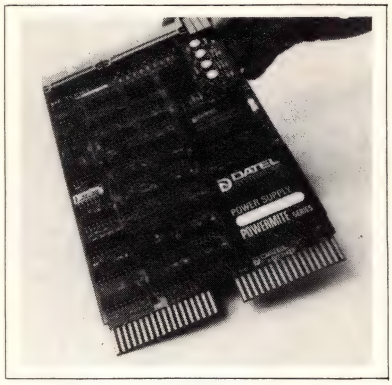
μC WITH A/D CONVERTER. Designed for data acquisition and direct control applications, the MLZ-DAQ sports either an ADAC ADAM-12 or ADAM-12APG A/D module to provide 32 (16 differential) 12-bit analog-input channels. This Z80-based single-board unit also provides two RS-232C ports, four Multibus-compatible parallel ports, 1k of static RAM and sockets for up to 8k bytes of EPROM. ADAM-12, $815 (100). **Heurikon Corp,** 700 W Badger Rd, Madison, WI 53713. Phone (608) 255-9075. **Circle No 252**



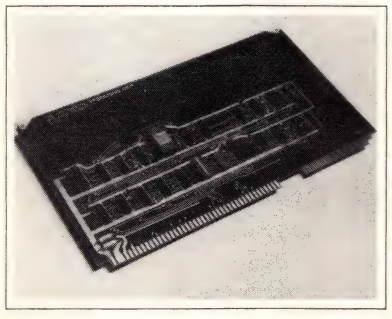
CORE MEMORY. With a 250-nsec access time and a 650-nsec full-cycle time, the Store/3220 provides 32k×20 bits of planar core memory per 11.75×15.4×1-in. board. You can link up to four of these cards for 128k maximum storage capacity. The memories are Micromemory-3000-interface compatible and are available with a self-test card option. $2190, in OEM quantities. Delivery, 120 days ARO. **Dataproducts Corp,** 6219 DeSoto Ave, Woodland Hills, CA 91364. Phone (213) 887-8451. **Circle No 253**



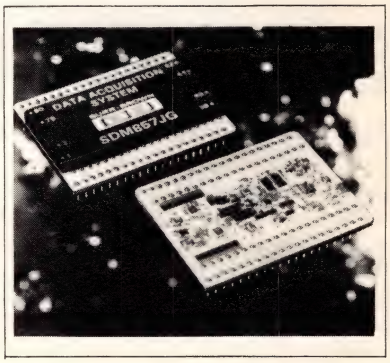
I/O BOARD. This S-100-bus-compatible board includes a 24-line×80-character video driver, 24 programmable parallel I/O lines, 24 dedicated output lines with bus-driving outputs, a UART with RS-232 interface and 1k byte of EPROM. The board also provides 4k bytes of refresh memory—so you can display 48 lines of video data by scrolling between lines—and it interfaces with all popular monitors. $395. **Micromation Inc,** 524 Union St, San Francisco, CA 94133. Phone (415) 398-0289. **Circle No 254**



LSI-11/2 A/D BOARD. On one half-quad board, the ST-LSI2 offers 16 single-ended or eight differential A/D channels for LSI-11/2 computers. Sporting a throughput speed of 20 μsec per conversion, the board furnishes a differential programmable-gain amplifier, a pacer clock with 16 program-selected timebases and a dc-to-dc power converter. $505 for ST-LSI2. **Datel Systems Inc,** 1020 Turnpike St, Canton, MA 02021. Phone (617) 828-8000. **Circle No 255**



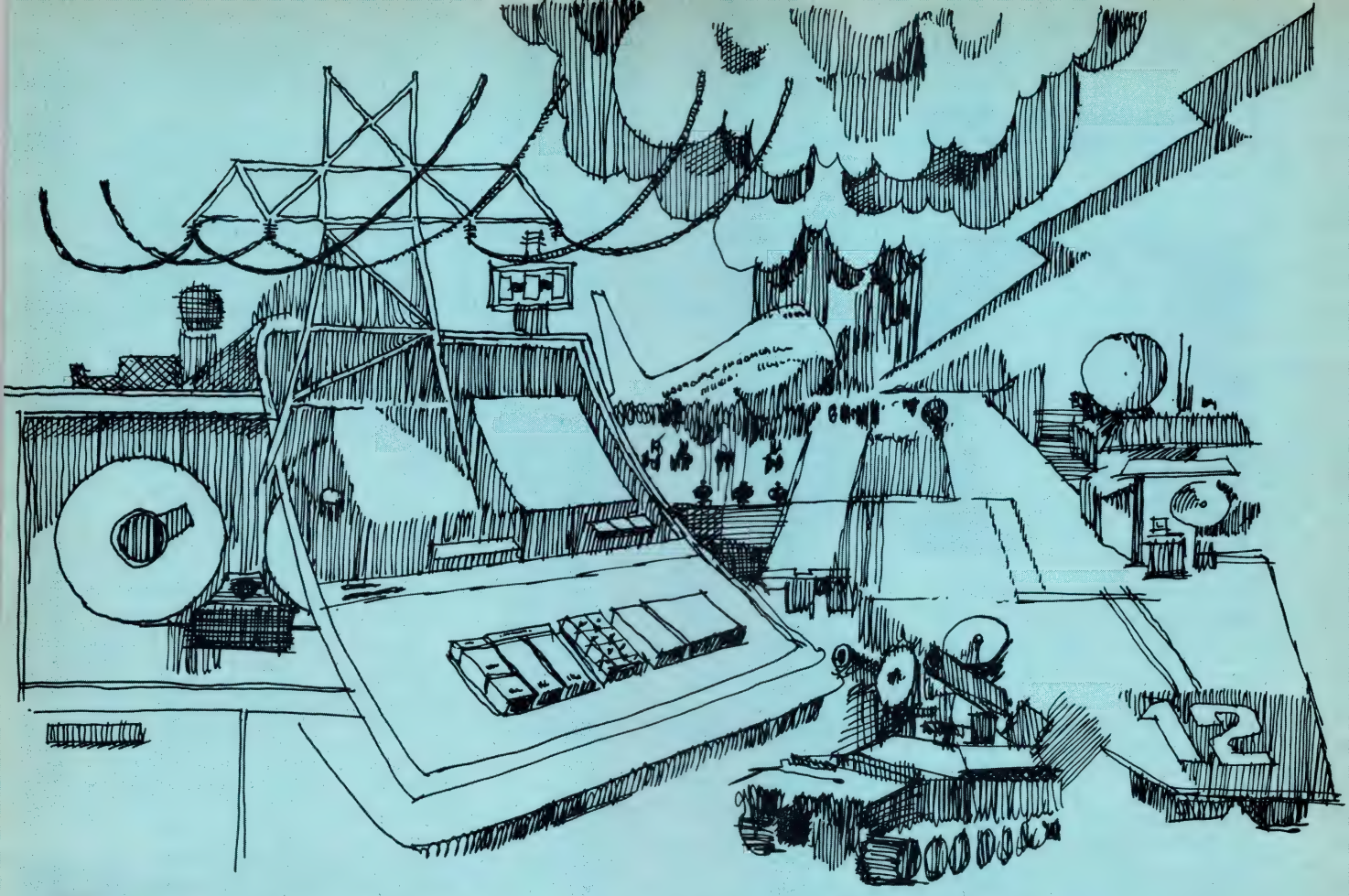
ARITHMETIC UNIT. Enhancing computational capability of SBC 80 systems, the AMC 95/6011 performs addition, subtraction, multiplication and division in either single-precision 16-bit fixed-point, double-precision 32-bit fixed-point or 32-bit floating-point formats. This one-board unit also computes advanced trig, inverse trig and log functions in a 32-bit floating-point format. $595. **Advanced Micro Computers,** 3340 Scott Blvd, Santa Clara, CA 95051. Phone (408) 988-7777. **Circle No 256**



DATA-ACQUISITION MODULES. Suited to the low-level signals associated with automatic test equipment and process-control systems, SDM856/SDM857 data-acquisition modules accept 16 single-ended or eight differential-input channels. The units offer 12-bit, ±0.01% linearity, and throughput sampling rates from 27 kHz. The SDM857 includes an instrumentation amplifier. SDM856, $99 (100); SDM857, $125 (100). **Burr-Brown,** Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. **Circle No 257**

DISC CONTROLLER. The Model 850 enables Nova- and Eclipse-type computers to accommodate up to four storage-module disc drives. Completely resident on one CPU chassis-compatible pc board, the controller emulates the Data General 606X. Features include automatic position verification, multiple computer access, implied seek and overlap seek for multiple-spindle applications. $3600. **Xylogics Inc,** 42 Third Ave, Burlington, MA 01803. Phone (617) 272-8140. **Circle No 258**

I/O MODULE. Available with up to eight RS-232C asynchronous serial-I/O ports, this 4-1/2×6-1/2-in. module suits applications such as data concentrators, key-to-disc systems and communications switches. You can select crystal-controlled rates ranging from 150 to 9600 baud. From $99 for a 2-port model. **Wintek Corp,** 902 N 9th St, Lafayette, IN 47904. Phone (317) 742-6802. **Circle No 259**



There's more than one kind of transient voltage ...and they're all a problem.

Ask a dozen engineers for a definition of transient voltage and you'll probably get twelve different answers because the word *transient* means different things to different people. Whatever the definition, they're all a problem. Transients are system killers if you're not careful. You can get them from induced lightning, static discharge, or from inductive switching. And, most of the trouble comes when you're dealing with tender devices such as T^2L, CMOS, memories, and other susceptible semiconductors.

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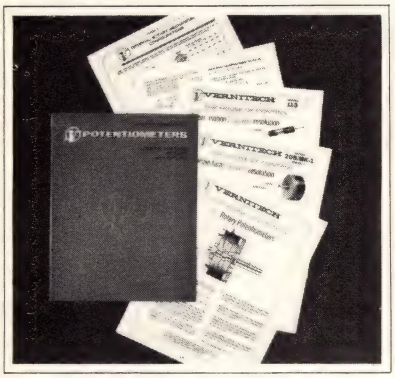
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Literature



Film-potentiometer line offers infinite resolution

The catalog section of this 48-pg handbook contains data on linear, rotary and multi-turn potentiometers. To help you select a precision product, a 9-pg data section covers mechanical design, element design, life, actuation speed, resolution, linearity or conformity limits, tolerances, power dissipation and much more. The catalog continues with product descriptions, options and a MIL-spec check list. **Vernitech,** Div of Vernitron Corp, 300 Marcus Blvd, Deer Park, NY 11729. **Circle No 224**

Guide to solid-state relays

The information section of this solid-state-relay booklet discusses ambient temperature, off-state leakage current, electrical load effects and environmental effects as they relate to SSR operation. The 15-pg brochure highlights design requirements of clamping networks, snubber networks and zero-voltage-turn-on circuits in SSRs; it also gives criteria for choosing optically-isolated, transformer-isolated or hybrid relays. Catalog No 7 illustrates and specifies the company's relays, including parameters of the output and input circuit. **Grayhill Inc,** 561 Hillgrove Ave, La Grange, IL 60525. **Circle No 225**

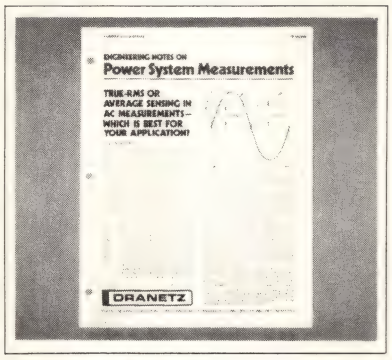
Computer-based apps for power sources

The latest issue of "Watts Up" features four tutorial miniarticles on power-source applications. Topics include temperature specifications, application-based power-source selection, power partitioning and uninterruptible-power-supply to backup-battery interfaces. New products and available literature are also reviewed. **Semiconductor Circuits Inc,** 306 River St, Haverhill, MA 01830. **Circle No 226**



Designer's manual on ion-implanted diodes

This 24-pg publication contains comprehensive specs for ion-implanted tuning diodes, PIN diodes and low-voltage avalanche Zener diodes, along with selection guides and a cross reference. It also includes information on the company's chips and leadless inverted devices (LIDs) for hybrid circuits, together with a description of screening procedures available to customers who require high-reliability devices. **KSW Electronics Corp,** S Bedford St, Burlington, MA 01803. **Circle No 227**

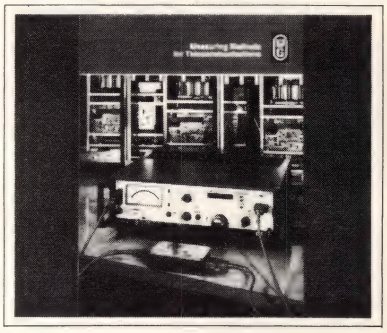


Dealing with waveform distortion

Fourth in a series, this 6-pg publication carries the title "True-RMS or Average Sensing in AC Measurements—Which is Best for your Application?" The paper begins by defining the problem: power-line waveforms almost invariably manifest distortions which have diverse effects on ac meters and different types of loads. The note considers peak, average and RMS measurements of a pure sinewave and points out the difficulties encountered with each when distortion occurs. **Dranetz Engineering Laboratories Inc,** 2385 S Clinton Ave, South Plainfield, NJ 07080. **Circle No 228**

New generation of chart recorders

A 6-pg data sheet examines a multipoint recorder series; its features and improvements include 25% greater point-handling capacity, individual chart motors and CMOS logic circuitry. A 2-pg illustration of the recorder's interior points out 20 important characteristics. Other photos depict thermal print heads, a programming panel and a slide-out chassis. **Leeds & Northrup Co,** MD210, Sumneytown Pike, North Wales, PA 19454. **Circle No 229**



Telecommunications: All about measuring

"Measuring Methods for Telecommunications," a 58-pg brochure, describes basic measuring-equipment design and solves telecommunication - measurement problems. The material includes text, schematics, line drawings and graphs which are grouped into sections: fundamental technologies of voltage- and level-measuring techniques; data-communication techniques; and distortion-measuring and PCM-measuring techniques. An additional section details the methods used in acquiring measured values. Please make requests on letterhead paper only. **W & G Instruments Inc,** 119 Naylon Ave, Livingston, NJ 07039.

INQUIRE DIRECT

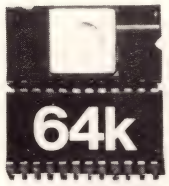
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For more information, Circle No 159

Literature



Bulletin simplifies application of displays

"Inspection, Handling and Installation of Beckman Displays," an 8-pg app note, provides device descriptions, procedures and recommendations for the inspection and installation of displays. Ten potential display defects are circled on separate photographs; the accompanying details give acceptable limits as well as instructions on what to look for. The final section recommends installation and handling techniques. **Beckman Instruments Inc,** Display Systems Div, Box 3579, Scottsdale, AZ 85257. **Circle No 230**

High-performance analog data system

Block diagrams, system configurations, timing diagrams and a complete list of specs can help you implement the manufacturer's System 256. This 16-pg brochure provides descriptions of available options that allow you to tailor the system's 256 expandable A/D and D/A channels to your specific application. **Datel Systems Inc,** 1020 Turnpike St, Canton, MA 02021. **Circle No 231**

Two 1979 instrument catalogs

One brochure describes digital panel meters and counters and their variations. The second catalog highlights a line of portable electronic test instruments, comprised of digital multimeters, oscilloscopes and frequency meters. Each pamphlet contains a price list and also lists accessory/optional-equipment costs. **Non-Linear Systems Inc,** 533 Stevens Ave, Solana Beach, CA 92075. **Circle No 232**



Unlimited applications for Sonalert signals

This bulletin lists more than 120 Sonalert audible-signal devices which electronically generate distinctive sounds. The 8-pg note describes the devices' capabilities and applications, gives technical information on audio, environmental and electrical specs and details case configurations. The back page points out 46 applications, including automotive, aircraft and marine warning systems. **Mallory Capacitor Co,** Box 1284, Indianapolis, IN 46206. **Circle No 233**

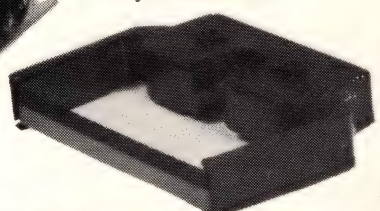
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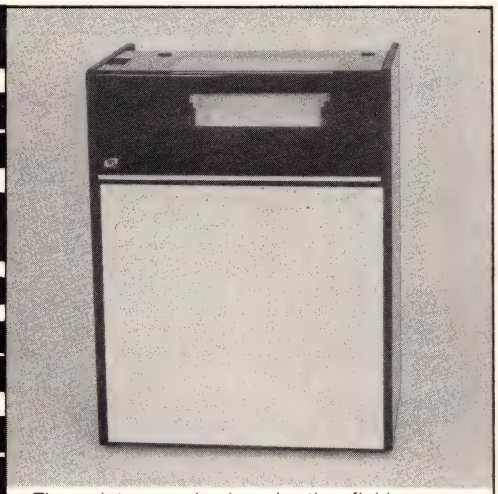
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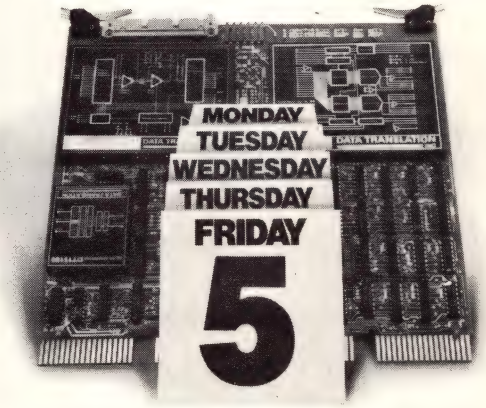
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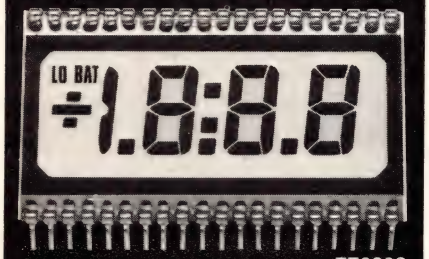
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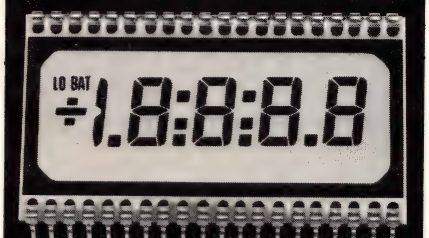
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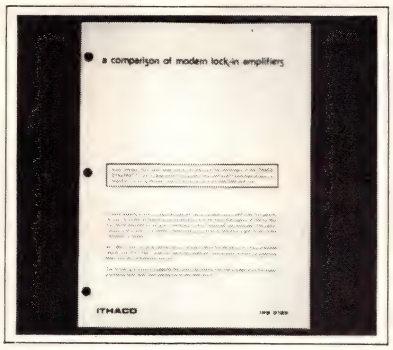
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Literature



Brochure compares modern lock-in amps

A 6-pg discussion gives basic lock-in amplifier concepts and offers brief descriptions of the various types available to researchers. The bulletin describes the company's Dynatrac concept, along with broad-band (flat-signal-channel), synchronous-heterodyne, manually-tuned, crystal-filter and pulse-width-modulated lock-in amplifiers. Listing characteristics of each technique, the paper graphically compares them to the theoretical "ideal" lock-in amplifier. **Ithaco Inc,** 735 W Clinton St, Ithaca, NY 14850. **Circle No 234**

Advantages/applications: pm motors and controls

Fully illustrated, this 86-pg motors and controls catalog gives complete specs, control definitions, prices, dimensions and applications. The controls section covers eight devices; the motor section includes selection charts that list 1/4- to 150-hp motors. It also explains the many benefits of using permanent-magnet motors over shunt-wound types. **B & B Motor and Control Corp,** 96 Spring St, New York, NY 10012. **Circle No 235**

How to detect defective or weak coils

"Coil and Winding Testing Notebook" covers small coils and windings, transformers, motor armatures and stators. The 24-pg brochure discusses the nature and causes of variations and defects, along with tips on practical methods of analyzing failures. Also presented are types of test equipment and techniques, an analysis of growler theory and a new approach to determining and specifying surge-test effectiveness. **Slaughter Co,** Box 1805, Ardmore, OK 73401. **Circle No 236**

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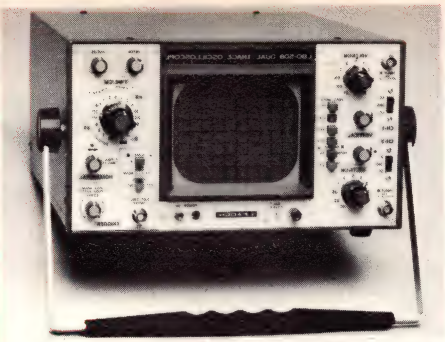


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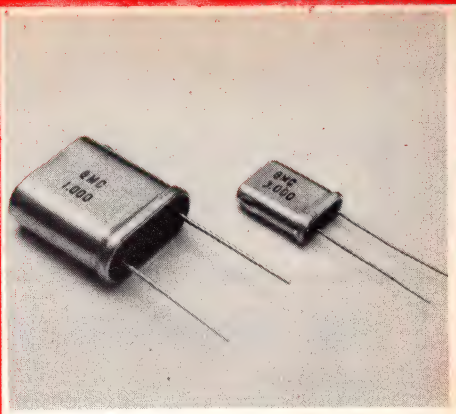
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Literature



Thermal-shock testing: concepts and design

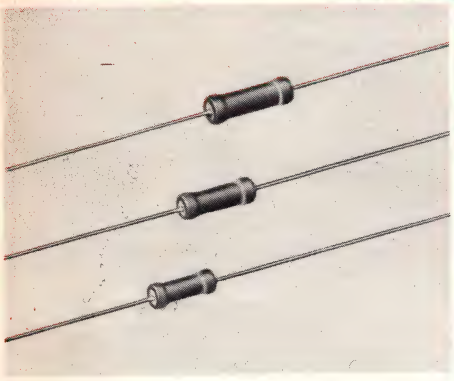
Bulletin #121J uses specs and applications to describe two basic thermal-shock units—a 2-station model and a 3-station model. The 4-pg sheet offers an introduction to thermal-shock testing, including how to use the company's testing chambers in MIL-SPEC programs. The note ends with a list of custom-design options. **Tenney Engineering Inc,** 1090D Springfield Rd, Union, NJ 07083. **Circle No 237**

Videotapes teach oscilloscope use

A videotape program entitled "How to Use an Oscilloscope" provides a basic education in the theory and practice of waveform measurement with oscilloscopes. The three-tape program runs 76 minutes; the first two tapes detail front panel controls, the last addresses measurements. Each cassette costs $300; large orders are discounted. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304.

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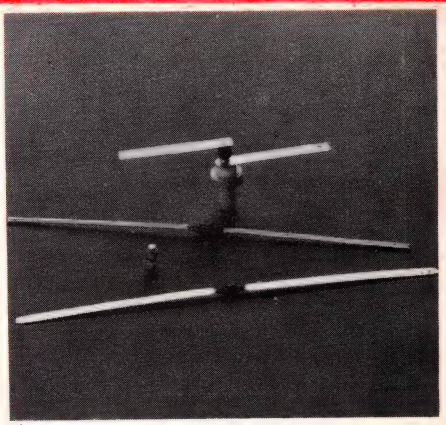


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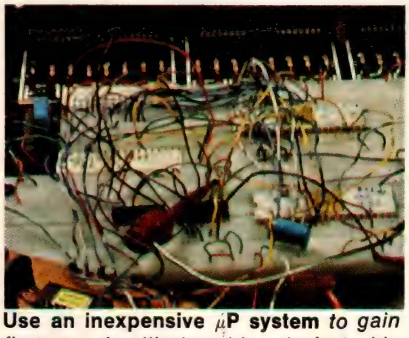
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Military computer systems *require fail-safe software (pg 41).*



Use an inexpensive μP system *to gain first-pass familiarity with today's 1-chip μCs (pg 84).*



On the cover: *This exaggerated photo of a Mark IV hammer hammers home the message of our Special Report on OEM printers (pg 68). (Photo courtesy Dataproducts)*

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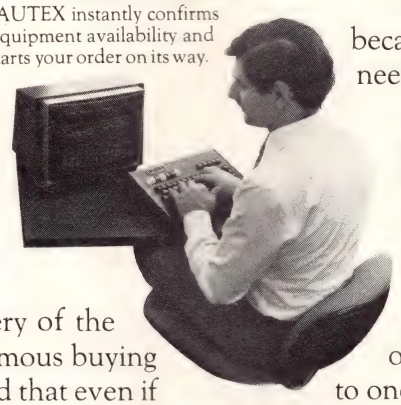
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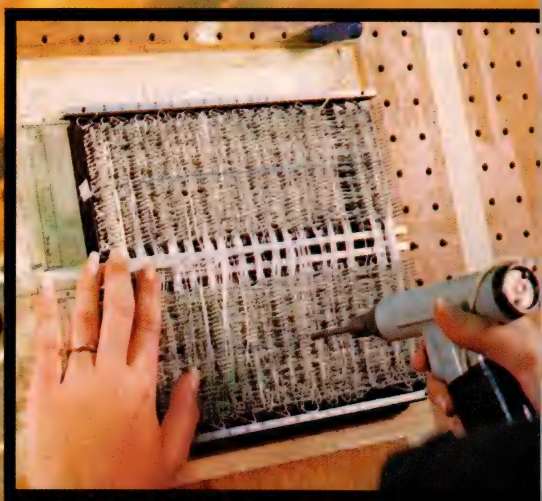
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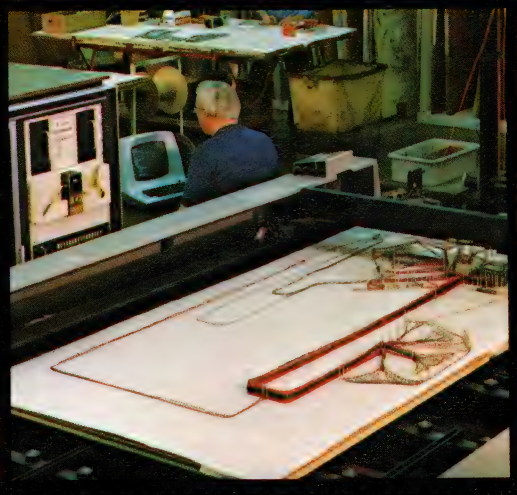
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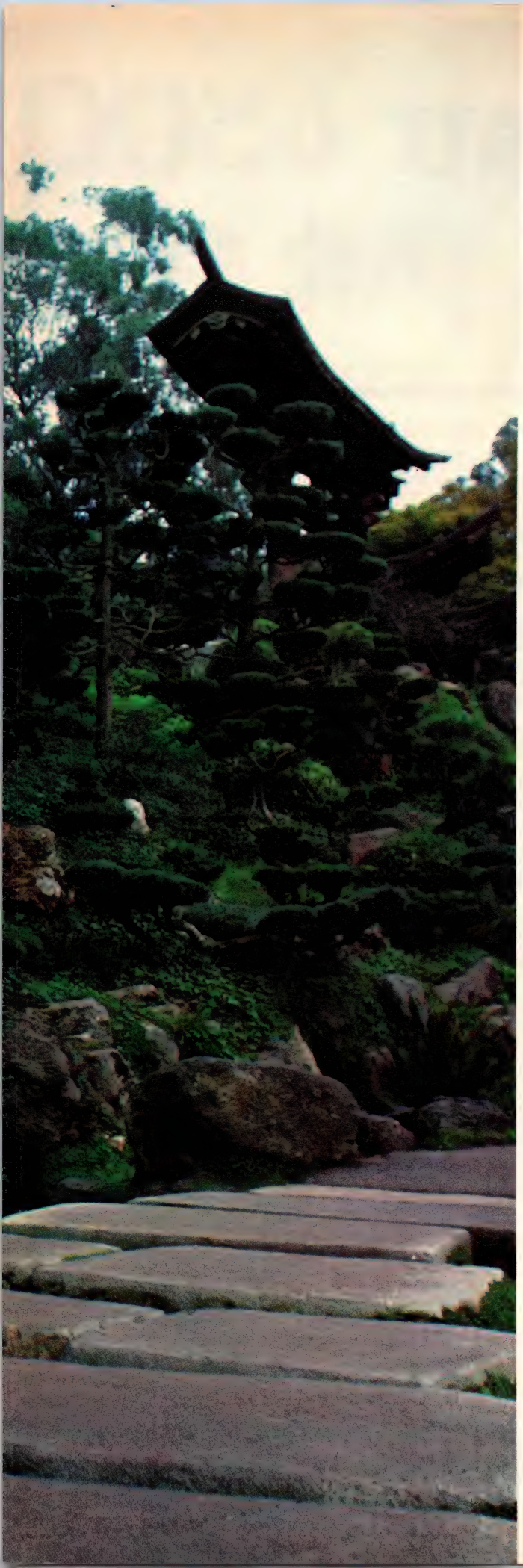
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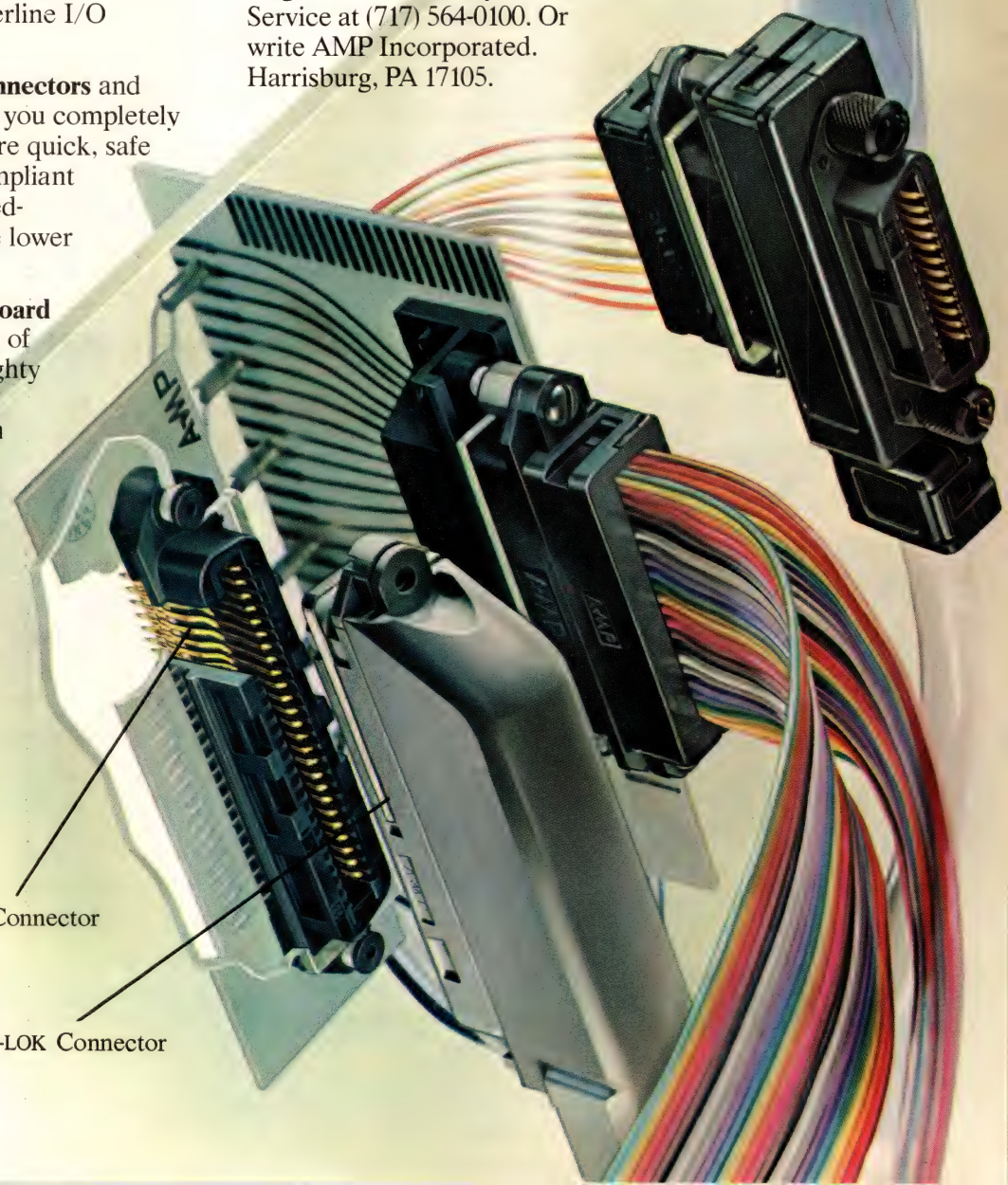
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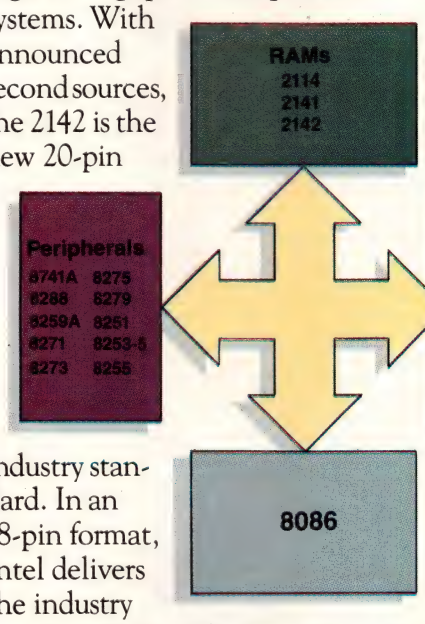
Key to practical microcomputer design is the EPROM. We invented these erasable and reprogrammable memories to make system prototyping faster and simpler. Now that the 8086 has extended the use of microprocessors to more complex data processing, the program flexibility of EPROMs is more important than ever.

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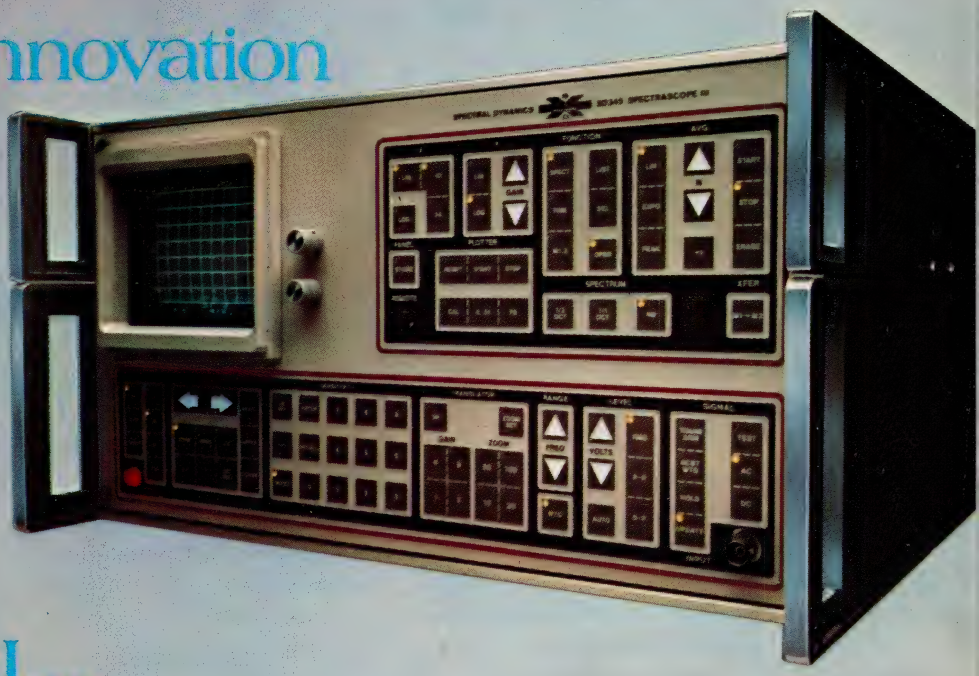
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Signals & Noise

Conservation begins at home

Dear Editor:

I read with great interest your November 20 news story, "μP-based home-control system stands guard and manages energy." I find the idea very promising and have worked on the task myself, but I find Bill Mandl's execution inefficient and unsuitable.

First, I think a $4000 to $6000 system cost (including installation) is far beyond what the average homeowner could afford and far beyond justification. Mandl's estimate of saving $400 to $500 each year is also hard to believe, even for an all-electric home — that amounts to 20 to 25 kWhr/day, which does not compare with the average home power consumption of 15 to 20 kWhr/day.

Further, Mandl's idea of saving power by using CMOS RAMs is very good, but why stop there? Why not a total CMOS system? I've worked on such a system, which dissipates less than a watt average power, compared with Mandl's 30 to 40W. On a continuous system such as this, those 30 to 40W become a sizeable electric load (almost 1 kWhr/day).

Thank you,
David V Campbell

Figuring out the figure

Dear Editor:

I must take exception to Dennis Van Dalsen's article on active-filter design (November 5, pgs 105-110). While the article achieves an introduction into the realm of active filters, certain concerns severely limit the usefulness of the designs presented, specifically the "equal - component - value" (ECV) Sallen-Key circuit (**Fig 8**).

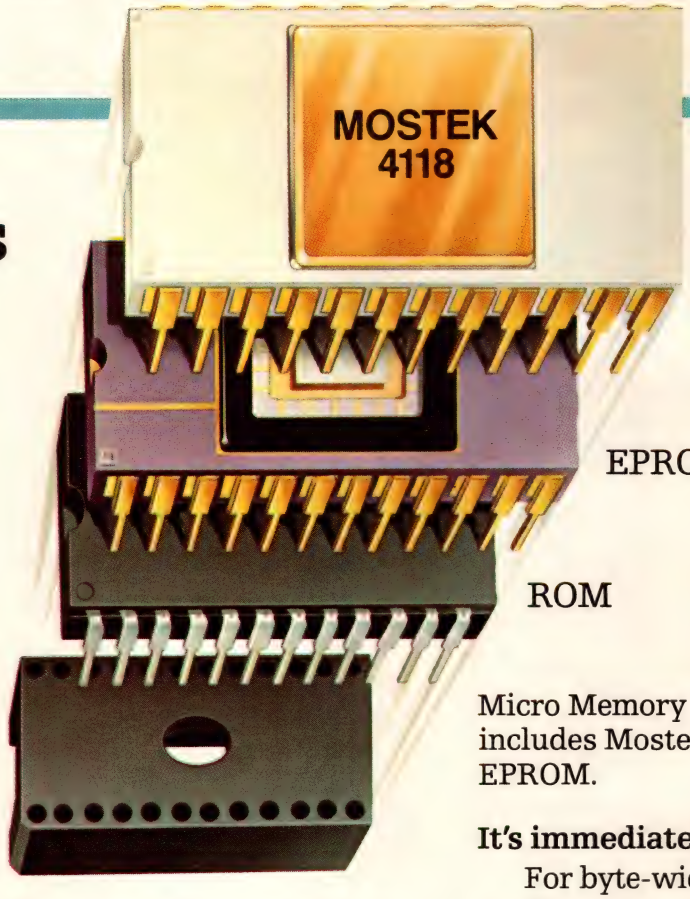
The rationalization for this circuit was to be able to use "standard-value capacitors." In reality, such capacitors can be used for the first circuit of **Fig 5** ($K=1, C_1=2C_2$) by judicious choice of R and C values and by using three capacitors of C_1's value. Using one capacitor for C_1 and the remaining two in parallel for C_2 achieves the desired result, if standard-value capacitors in a 2:1 ratio cannot be found.

An examination of the sensitivities of the network parameters shows that the ECV Sallen-Key circuit is less desirable than the circuit of **Fig 5**. Using the equations from *Operational Amplifier Design and Applications,* the sensitivities of ω_0 to changes in R_1, R_2, C_1 and C_2 are all $-1/2$ for both circuits. Thus, 1% changes in component values result in $-1/2$% changes in ω_0. This value is fixed and independent of circuit design, and hence is the same for both circuits. However, the sensitivity of α ($\alpha=1/Q$) to the component values and to amplifier gain is another story. The sensitivities of α to the components for both circuits are as follows:

COMPONENT	FIG 5	ECV
R_1	0	−0.21
R_2	0	+0.21
C_1	−0.5	−0.91
C_2	+0.5	+0.91
K	−1.0	−1.21

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While the sensitivity of α with respect to K is relatively high for both circuits, in the case of the circuit of **Fig 5**, K is determined by a piece of wire and the amplifier open-loop gain; there is little chance of it changing. In the ECV circuit, K is determined by two resistors.

The article also states that peaking or damping of the ECV circuit can be easily adjusted. No mention is made of the fact that the bandpass gain also changes as Q is adjusted—usually undesirable in an active-filter design.

Also, I believe there are a couple of typographical or artist errors. The Q for a critically damped circuit is $1/\sqrt{2}$, not $\sqrt{2}/2$ as stated in the article.

Sincerely,
John Keller
Applications Specialist
Dataproducts Corp
Woodland Hills, CA

(Ed Note: Mr Keller is indeed correct—$1/\sqrt{2}$ is $\sqrt{2}/2$, not $\sqrt{2}/2$ as stated. The author's reply follows:)

Dear Mr Keller:

I would like to extend a hearty thanks for your comments on my November 5 article on active filters. Your evaluation of the Q sensitivity factors and the Q vs bandpass gain of the ECV Sallen-Key is an excellent example of the careful attention that must be paid when selecting an active-filter type.

Clearly, this article will not qualify as the last word on active-filter design, and your inputs support this view.

Unfortunately, most readers do not have the extensive background necessary to be classified as experts in active filters. It was my intention to clear some of the fog that normally surrounds active filters by demonstrating their usefulness and simplicity through just a few of the nearly infinite variety of circuit configurations. I hope that I have been at least somewhat successful in this endeavor.

Sincerely,
Dennis Van Dalsen
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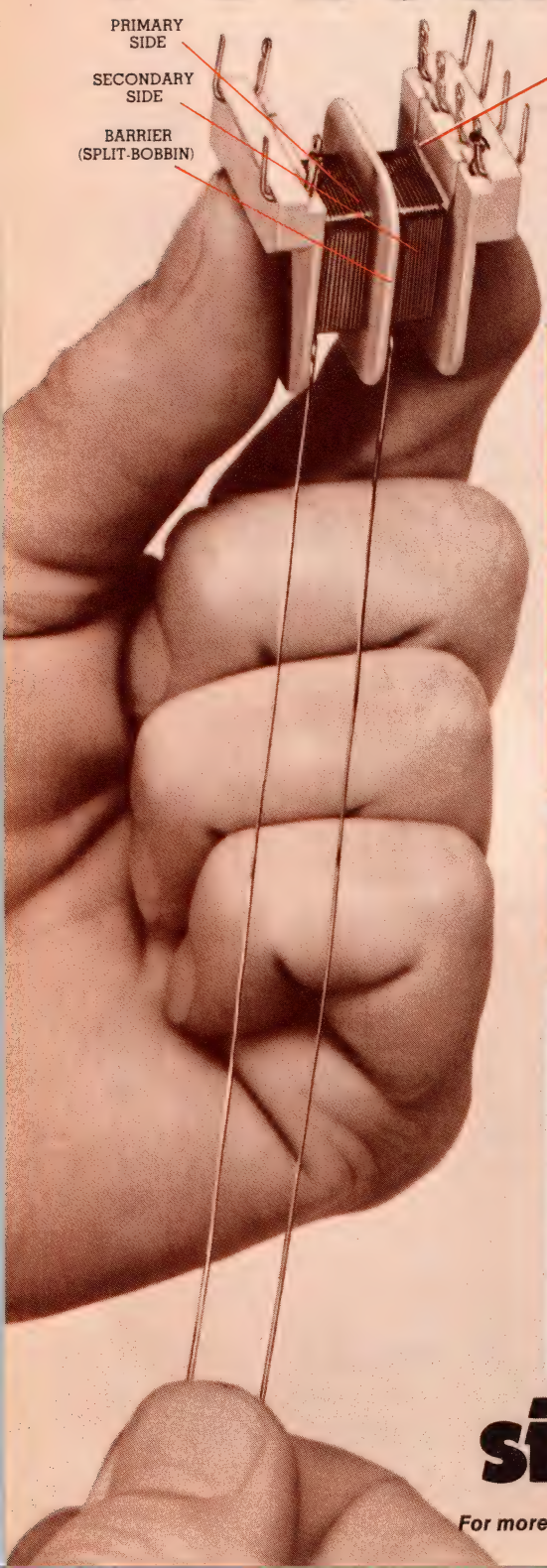
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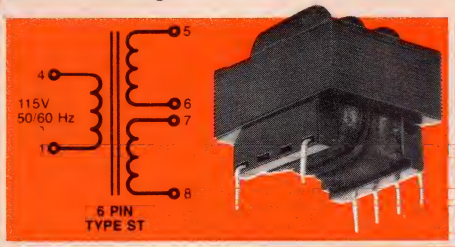
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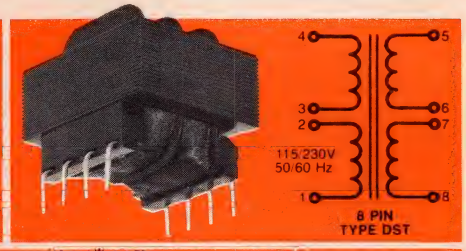
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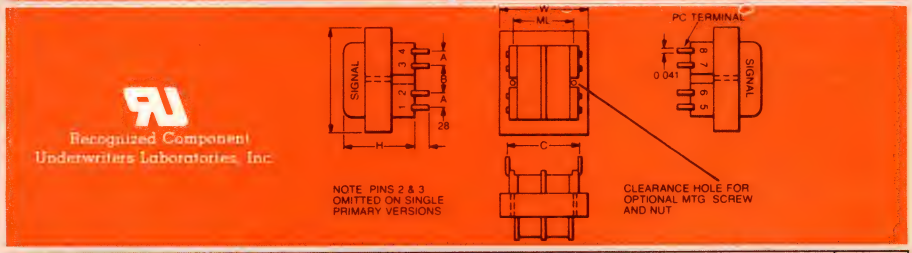


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ST 5-16	DST 5-16	16V C.T. @ 0.8A	8V @ 1.6A	ST 5-48	DST 5-48	48V C.T. @ 0.25A	24V @ 0.5A
ST 6-16	DST 6-16	16V C.T. @ 1.25A	8V @ 2.5A	ST 6-48	DST 6-48	48V C.T. @ 0.4A	24V @ 0.8A
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ST 6-20	DST 6-20	20V C.T. @ 1A	10V @ 2A	ST 6-56	DST 6-56	56V C.T. @ 0.35A	28V @ 0.7A
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ST 5-24	DST 5-24	24V C.T. @ 0.5A	12V @ 1.0A	ST 5-120	DST 5-120	120V C.T. @ 0.1A	60V @ 0.2A
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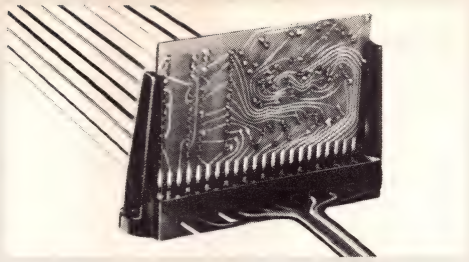
In our November 5 editorial, we invited EDN readers to comment on the practice by some semiconductor manufacturers of announcing new products long before they are realistically available to designers. It seems that some readers have encountered this situation, and they have made their thoughts perfectly clear, as demonstrated in the following selection of reactions.

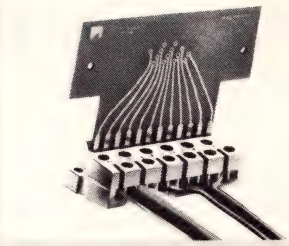
Vendor-availability estimates are useless (I add 4 to 12 months). I believe that a product is real when my local distributor has received several shipments over a several-month span. Too many products vanish between sample and production.

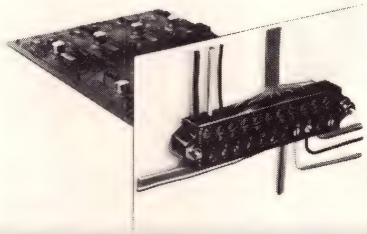
I believe a vendor's claims when I have a 6-month supply of its part on hand—preferably from its competitor, too. Have you ever had $5 million worth of product sitting waiting for a part? It's no fun!

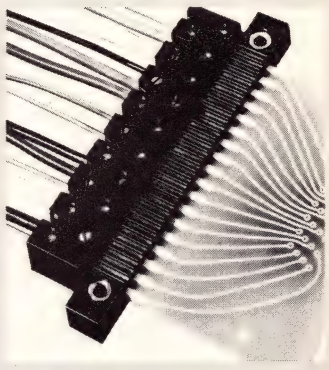
As any engineer knows, you always multiply delivery estimates by π.

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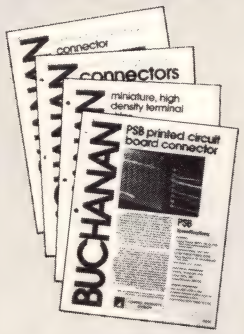
In production, BUCHANAN I/O Connectors save even more — particularly if much wiring is done after mechanical assembly. Experts agree — such operations should be a *screwdriver job* — neat, quick, and efficient, minus dangling leads, twisted cables, and awkward soldering or wire-wrapping locations.

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*U.S. Patent No. 3,930,706. Other patents pending.



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For more information, Circle No 16

into your circuit unless you have it in your hot little hands. You can't design on promises.

I always take new-product announcements with a grain of salt because I have been stung by designing-in a part that turned out unavailable.

Murphy's Law and others

Dear Editor:

For some time I have been collecting these little truisms and their various corollaries. I am sure people will be able to find several that apply to their situations.

Very truly yours,
William D Kraengel, Jr

PS: I won't reveal the name of my company lest someone get the wrong idea. Murphy notwithstanding, occasionally we *do* get something right.

- If there is a possibility of several things going wrong, the one that *will* go wrong is the one that does the most damage.
- The light at the end of the tunnel is the headlamp of an oncoming train.
- By making something perfectly clear, someone will be confused.
- Repeatability is the absolutely consistent recurrence of an erroneous result.
- Whatever project you set out to do, some other project must be done first.
- Every great idea has a disadvantage equal to or exceeding the greatness of the idea.
- After major equipment has been repaired and reassembled, parts will be noticed on the floor.
- The more ridiculous, stupid and dumb an idea is, the better chance it has of catching on.

Your turn...
EDN welcomes your comments, pro or con, on any issues raised in the magazine's articles. Address letters to **Signals and Noise Editor, EDN, 221 Columbus Ave, Boston, MA 02116.** Names will be withheld upon request. We reserve the right to edit letters for space and clarity.

Our new ChainTrain® 1210 zips along at 1000 LPM's ... and has inherited the best features of its 1200 LPM big brother.

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Hewlett-Packard: "We use two 3870s in our 7225A Graphics Plotter because of their low cost, 2K ROM memory and interfacing ease. The result is an economical and highly versatile graphics plotter." *John Fenoglio, R&D Project Manager*

John Fluke: "The unique timer on Mostek's 3870 provides the one microsecond resolution our 2180A/2190A Digital Thermometer needs. The 3870 also replaces all digital IC's while allowing more features." *John Lund, Senior Design Engineer*

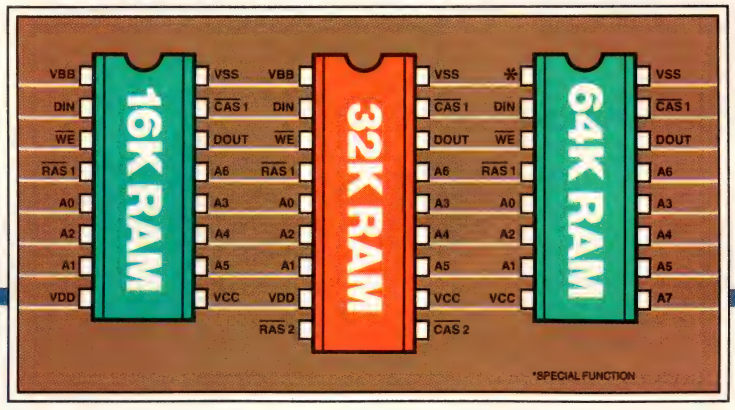
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When 64K RAMs are available, your 32K system can be totally compatible.

Design in flexibility.

You can design memory systems that interchange 4K, 16K, 32K and 64K dynamic RAMs. The MK4332, organized as 32K x 1, mounts two 4116s in leadless chip carriers connected to a standard 18-pin dual-in-line package. The two chips share common Address, Data In, Data Out, Write Enable and power pins. Separate $\overline{RAS}$ and $\overline{CAS}$ clocks for each 4116 are provided for easy device selection and control. The arrangement of all other pins is identical to the industry standard 16-pin configuration for 4K and 16K RAMs. The pin configuration is also compatible with Mostek's soon-to-be-announced 64K RAM, the MK4164.

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Access time for the high density 4332 is a fast 200ns with a cycle time of just 375ns. Because both 16Ks feature an Edge-Activated™ selection mode, one chip remains in standby while the other is activated. This means the 4332 dissipates just 482mW while active and 40mW during standby. It allows a ± 10% tolerance on all power supplies (+ 12V, ± 5V).

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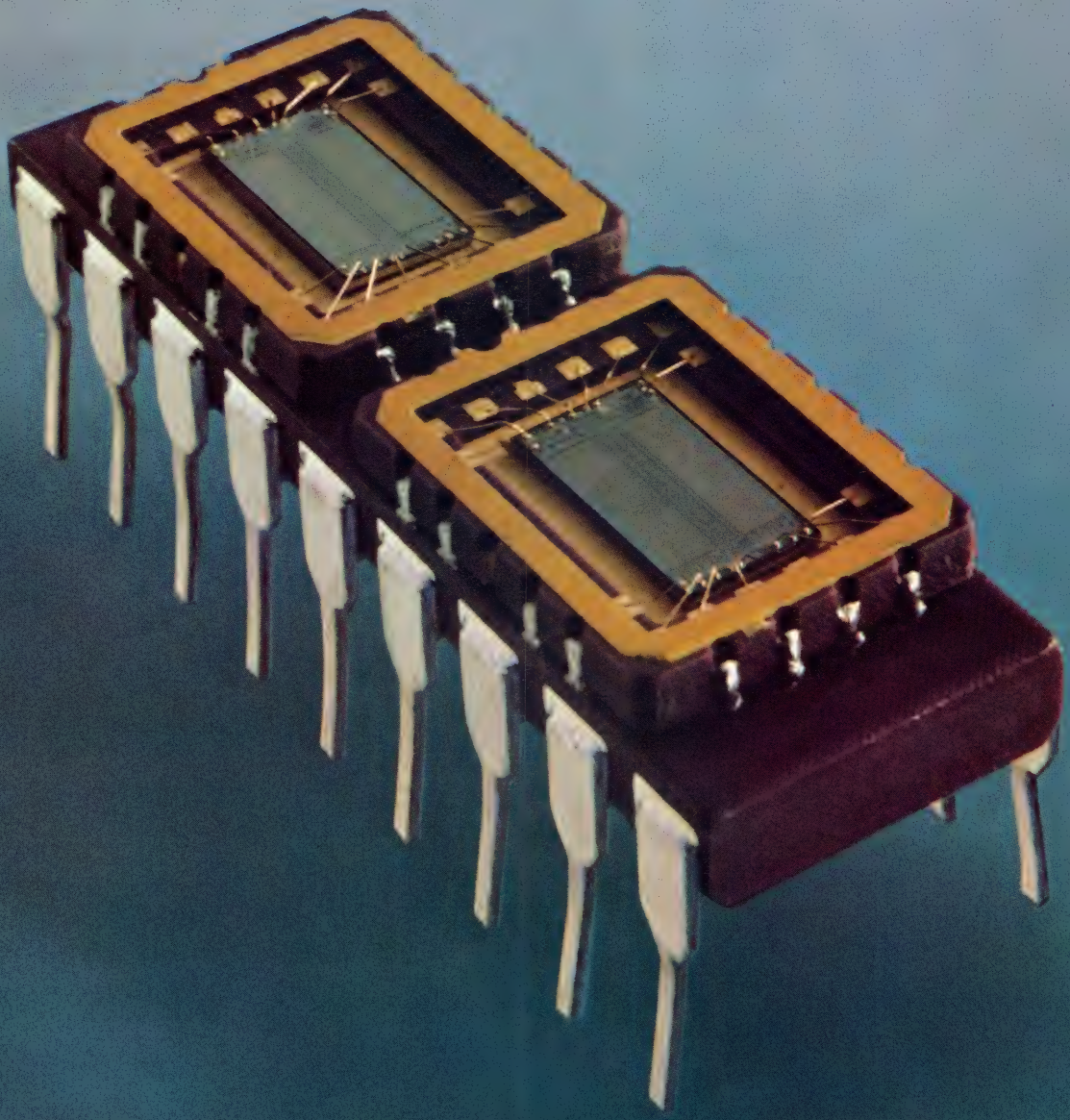
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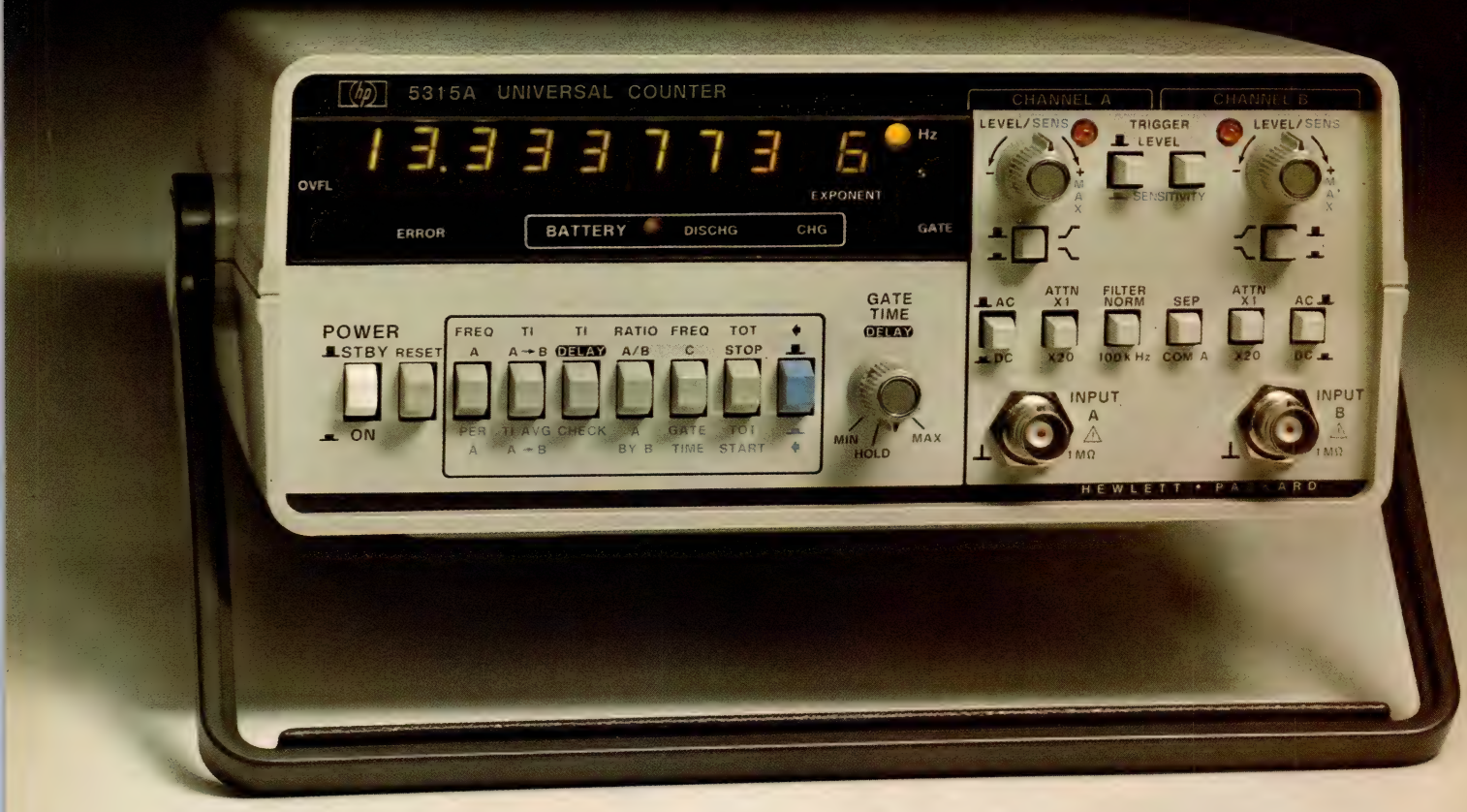
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With our 32K RAM.



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HP has just re-invented the universal counter.



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02825A

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You're Never In The Dark About Triggering

Trigger lights are off if the trigger level is set too high to count, they'll blink when counting takes place, and they are fully illuminated when the input amplitude is above the trigger level.

Faster, More Accurate Measurements

Now you can have frequency measurements significantly more accurate than with conventional counters. This is possible because the 5315A measures period and computes and displays its reciprocal—frequency.

The 5315A gives at least 7-digit resolution, (0.0001%) in 1 second, for inputs from 1 Hz to 100 MHz. By contrast, in the same time, conventional counters can resolve 1 kHz to only 0.1% and 10 Hz to only 10%. At last, the 5315A's advanced technology finally brings reciprocal counting out of the $2000 range.

And, for higher time base stability, HP offers a temperature compensated crystal oscillator (TCXO) option.

Continuously Variable Gate Times

Being limited to decade values of gate times are a thing of the past. The 5315A gives you continuous adjustability from 50 ms. to 10s, and the instrument will measure it precisely if you wish. This means:
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- You get automatic selection of sample size in period and time interval averaging for easy, confident trade-offs between accuracy and measurement time.
- You get a more stable readout for many measurements.

A Faster, More Certain Readout

Just glance at the big, bright, amber LED's and see how easy it is to read and interpret. The display is in engineering units—a 6 exponent for MHz, −6 for μs. It thinks the way you do.

New Confidence in Time Interval Measurements

A new dimension has been added to HP-pioneered time interval averaging: The 5315A internal CPU truncates the display to a resolution that is in keeping with the accuracy. No longer are there the extra, meaningless digits you've seen in the past.

Perhaps the Quietest Counter Ever

The 5315A will pass Germany's VDE 0871/0875 level A limits for electromagnetic compatibility, and the metal-cased 5315B will pass U.S.A.'s MIL STD 461 on RFI. Both are excellent for RFI sensitive measurements such as receiver testing.

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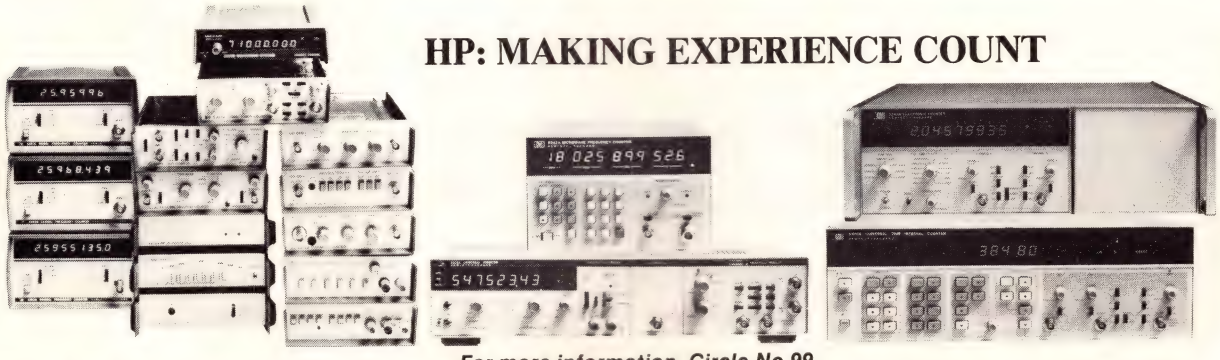
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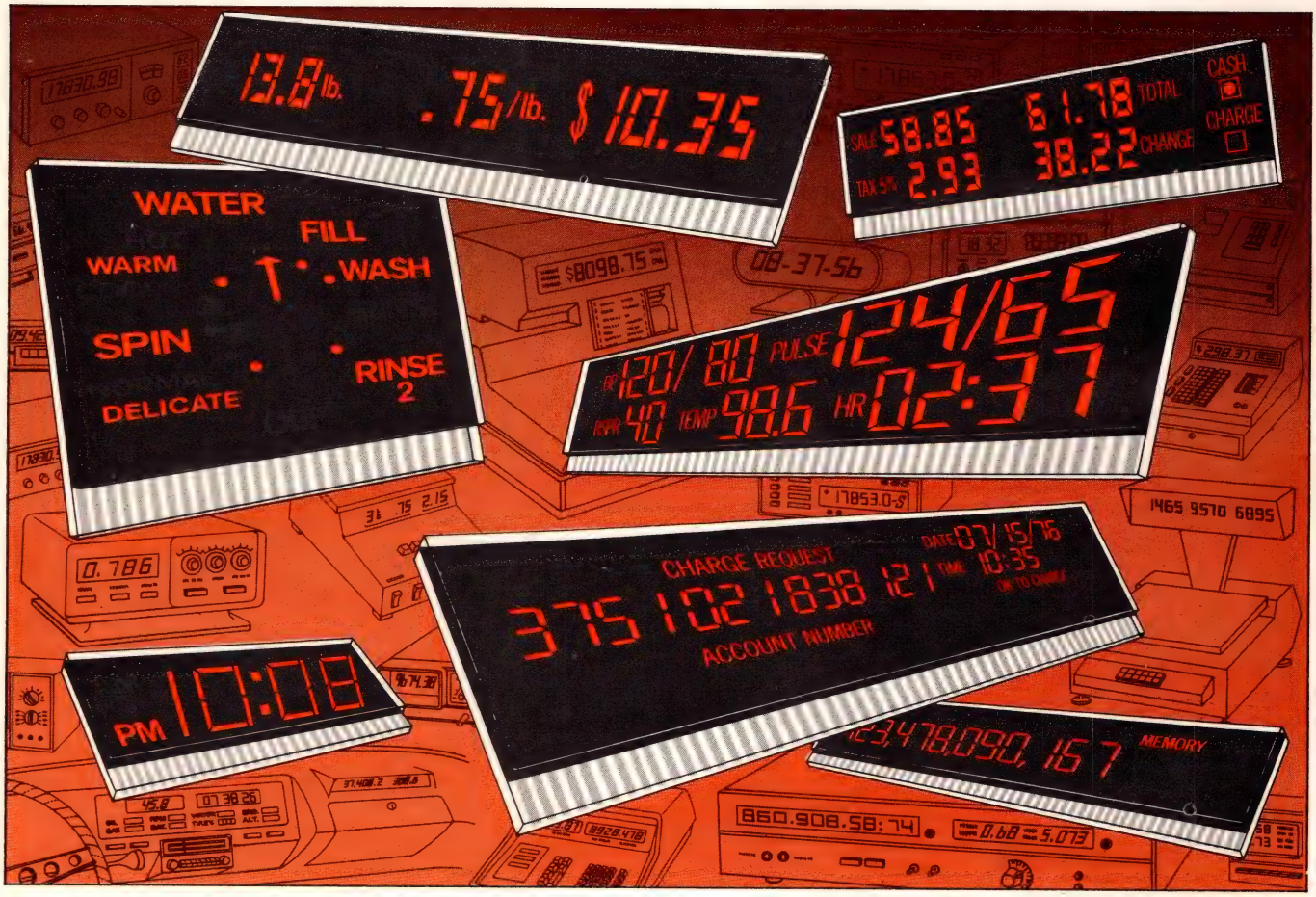
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Here's a vivid demonstration of the suitability of the Screened Image Technology for producing large fields of versatile, 14-segment characters. The SP-452 provides 16 characters, each with its own decimal point and comma. The half-inch size is ideal for point-of-sale equipment and in other applications where large field, alphanumeric capability is needed. The 14-segment format makes possible a display set of the ten numerals and the alphabet plus special symbols — providing a character set that can be as versatile as you want to make it.

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Editorial



The invasion of the market snatcher

We admit it. Like many of you, we're devout IBM watchers. But until recently, our activities reflected merely personal interest. Because EDN serves the OEM portion of the electronics industry and not the large-system, end-user, data-processing market, the giant computer maker's moves haven't previously affected too many of our readers. However, during the past six months the competitive situation in the small-computer-systems arena has changed significantly, and as a result, our IBM watch is no longer an idle diversion—it's become a deadly serious concern.

IBM's significant new product introductions (the 8100 and E Series machines, in particular) and its unusually aggressive pricing policies (such as the recent 370/303X memory price cut) clearly indicate that it has taken direct aim at low-end 370-compatible mainframes and—more importantly—at the products and markets served by the traditional small-computer manufacturers. And when IBM takes aim, it generally hits its target with a considerable impact.

Alas, technologists miss the point when they scoff at IBM for being overly conservative. They point out that many of the firm's products can be readily upgraded in performance or made smaller, or less costly. And they're correct in this judgement—as the viability of the plug-compatible market shows. Nevertheless, in making such a judgement, these technical purists overlook a significant fact: IBM designs its products for manufacturability—then superbly markets, services and supports them.

Consider the example of just one component: IBM's 64k RAM. True, the chip is large, relatively slow and utilizes technology that leading semiconductor houses would consider outdated, if not totally obsolete. Nevertheless, this device is the only one of its type currently in volume production. And it's already making an impact on the market by freezing future computer-system orders.

Is there a bright side to this gloomy picture of the corporate giant preparing to devour the OEM computer industry? Fortunately, yes. When IBM blesses a technology, product or idea, sales resistance weakens and new opportunities open up to everybody. (The concept of low-cost distributed-processing systems is currently getting the biggest boost.)

Although discussions concerning IBM can go on for days, perhaps we can most usefully summarize our insights as follows:

- If you don't consider IBM a current or potential competitor, perhaps you should rescan your horizons.
- Manufacturers of IBM-compatible equipment could soon be forced to rethink their engineering or marketing strategies and offer more than just a price advantage to obtain market share.
- Creative engineers who study IBM's moves closely can uncover untapped market niches that offer the possibility of personal and corporate success.

But whatever your reactions to IBM or to these viewpoints, if you're not already a member, welcome to the ever-expanding IBM observation/conversation/speculation/analysis club.

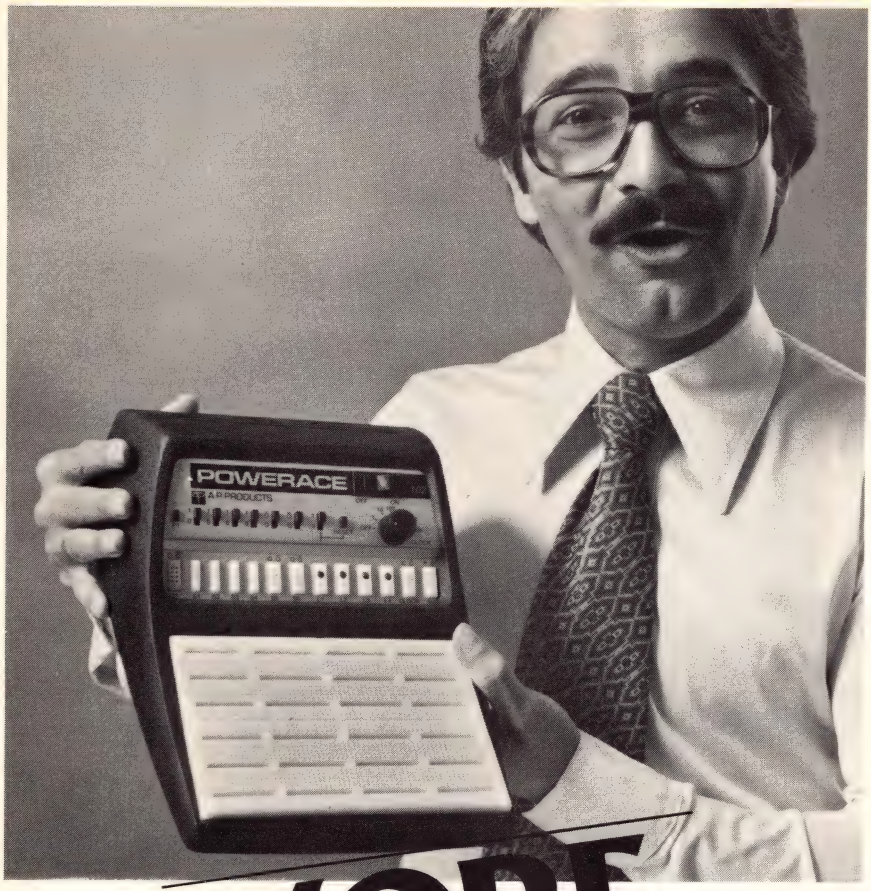
Walt Patstone

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Editor

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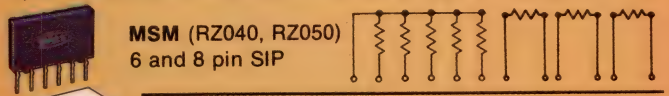


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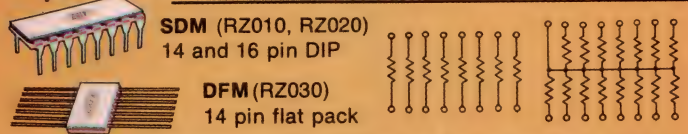
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Books

Getting to know the Z80

Z80 Microcomputer Handbook, *by William Barden Jr, Development Labs Inc, Santa Monica, CA. 304 pgs; $8.95 softbound; Howard W Sams & Co Inc, Indianapolis, IN, 1978.*

A cross between a reference work and how-to-use-it book, this handbook provides an agreeable introduction to the Z80 μP. Although it doesn't contain everything you need to know, it gives a thorough, if general, treatment of the device's architecture. The sections on software and Z80-based μCs, however, could have been better spent in presenting more detail on topics covered in the first section.

The book's segmented organization suits easy reference, which proves helpful when using it as a supplement to existing system documentation, but unfortunately also disturbs the continuity of the overall discussion. Within each topic, however, each discussion evolves logically from a general viewpoint to a more specific analysis pertaining to the Z80.

Thus, much of the information supplied in the handbook is not only applicable to the Z80 μP; the work also serves as an introduction to μPs in general.—***Edward R Teja***

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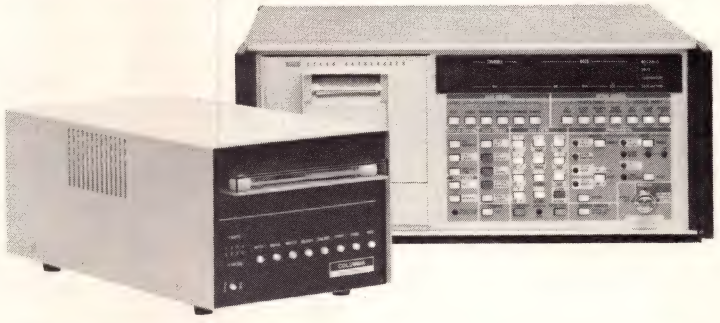
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Leadtime Index

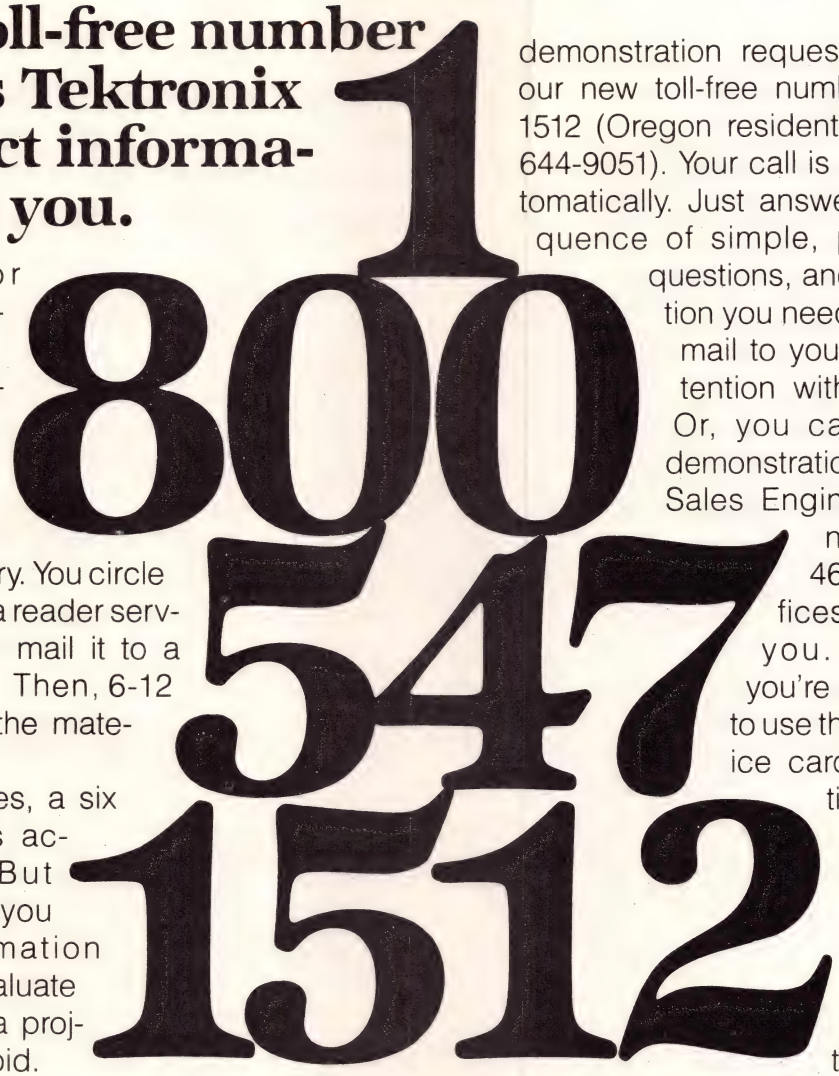
ACTIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS Min	Max	Trend
DISCRETE SEMICONDUCTORS			
Diode, switching	7	10	=
Rectifier, low-power	6	9	=
Rectifier, power	6	8	=
Regulator, zener	9	13	=
Thyristor, low-power	6	11	=
Thyristor, power	9	12	=
Transistor, bipolar power	6	10	=
Transistor, bipolar signal	7	11	=
Transistor, field-effect	7	11	=
Transistor, RF power	6	10	=
DISPLAYS			
Electromechanical	10	14	=
Fluorescent	12	15	=
Gas-discharge	4	12	=
Incandescent	8	12	=
LED	8	12	up
Liquid crystal	7	9	up
Plasma panel	10	16	up
ELECTRON TUBES			
CRT, black and white TV	8	12	up
CRT, color TV	7	9	up
CRT, industrial	10	12	up
Industrial power	4	6	=
Light and image sensing	10	15	=
Microwave power	15	18	up
INTEGRATED CIRCUITS, DIGITAL			
CMOS	12	15	up
Diode transistor logic (DTL)	14	19	up
Emitter-coupled logic (ECL)	15	19	up
Standard TTL	12	17	up
Schottky TTL	16	23	up
INTEGRATED CIRCUITS, LINEAR			
Communications circuit	16	18	=
Data converter	9	11	=
Interface circuit	17	21	=
Operational amplifier	9	12	=
Timing circuit	9	13	up
Voltage regulator	10	14	up

PRODUCT	LEADTIME IN WEEKS Min	Max	Trend
MEMORY CIRCUITS			
CCD	6	12	up
EPROM	9	20	up
PROM, bipolar	12	16	=
RAM, bipolar	11	14	=
RAM, CMOS	10	16	up
RAM, 4k MOS dynamic	16	26	up
RAM, 16k MOS dynamic	13	18	up
RAM, 1k MOS static	1	4	=
RAM, 4k MOS static	8	26	up
ROM, masked MOS	11	16	up
Shift register	5	9	=
METERS			
Analog panel	12	18	up
Digital panel	11	16	up
MICROCOMPUTER/MEMORY SYSTEMS			
Core memory board	4	13	up
IC memory board	4	13	up
Interface board	4	13	up
Microcomputer board	4	13	up
MICROPROCESSOR IC'S			
CPU, bipolar bit slice	8	12	=
CPU, 8-bit MOS	7	11	=
CPU, 16-bit MOS	7	13	=
Peripheral chip	7	13	=
OPTOELECTRONIC DEVICES			
Coupler and isolator	11	14	=
Discrete light-emitting diode	18	20	=
PACKAGED FUNCTIONS			
Amplifier, instrumentation	14	18	up
Amplifier, operational	16	20	up
Amplifier, sample/hold	16	22	up
Converter, analog/digital	5	11	=
Converter, digital/analog	5	11	=
POWER SUPPLIES			
Custom	11	13	=
Enclosed modular	10	12	=
Open-frame module	10	12	=
Printed circuit	10	12	=

Leadtimes are based on recent figures supplied to *Electronic Business* magazine by a composite group of major manufacturers and OEMs. They represent the typical times necessary to allocate manufacturing capacity to build and ship a medium-sized order for a moderately popular item. Trends represent changes expected for next month.

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Waiting for weeks to receive product information has become a custom in the electronics industry. You circle a number on a reader service card and mail it to a publication. Then, 6-12 weeks later, the material arrives.

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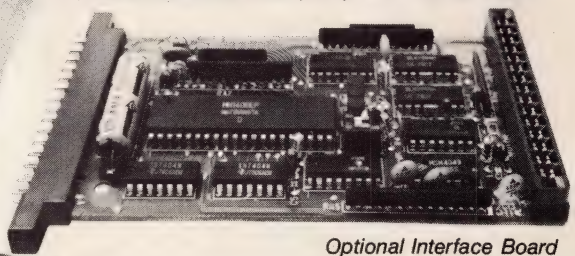
It isn't even the fact that the package is small (4.33″L x 3.5″W x 1.5″H). That makes it great in tight applications like POS cash registers, electronic calculators, data loggers, home computers and general peripherals—anywhere, in fact, where inexpensive hard copy is required.

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Military software initiative could have civilian fallout



Computer systems in critical military applications *such as this F-15 fighter demand software that works perfectly every time. (US Air Force photo)*

Joan Morrow,
Editorial Assistant

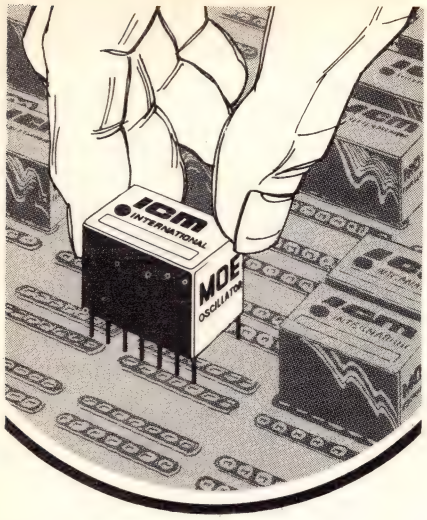
Producing fault-free software apparently lies just beyond the grasp of anyone trying to whip wayward code into line; achieving this goal would require that software be mass produced and subjected to testing disciplines now available only to hardware designers. But a Department of Defense (DOD) initiative scheduled for Congressional approval this summer aims at overcoming software barriers to progress in system design, and it could signal the end of the software craft as programmers know it today.

Software's inability to keep up with the rapid pace of hardware innovation has resulted in its accounting for 70 to 90% of a new computer system's cost, according to DOD estimates. Traditional industry methods of handling this problem include bypassing software completely in system design.

As an example of the current software bottleneck, note that while quality-control procedures yield high levels of user acceptability, the DOD has documented data showing an average error rate of one error for every 300 instructions in tested systems.

What price reliability?

Acceptability thus does not always imply reliability, and that is the DOD's major software constraint. The initiative's founder and chief backer, Ruth M Davis, Deputy Under Secretary of Defense for Research and Engineering, claims it "will



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International Crystal Manufacturing Company, Inc.
10 North Lee, Oklahoma City, Oklahoma 73102

For more information, Circle No 28

Technology News



Dr Ruth M Davis, *Deputy Under Secretary of Defense for Research and Engineering, intends to subject computer software to the same rigorous standards required of hardware design.*

produce significant and needed improvements for the surer application of computers—the single most important tool of our time."

In a presentation at MIT last fall, Davis stated that the DOD's first priority is software reliability throughout a system's lifetime, with performance a close second. In contrast, the nonmilitary user usually looks for the least expensive product, then checks out its performance and reliability. But because the DOD must aim for superior weapon performance, reliability often suffers with increased weapon complexity.

Price wars

Cost has continually been an indicator of software-dependent problems. Davis estimates that $50 million could be saved each year if a programmer's daily output of 10 lines of code (the same average output as in the 1950s) were increased to just 11 lines/day. Similarly, reducing software test and verification time by 1 man-day each month would amount to a $75 million DOD savings yearly.

Even though the DOD spends at least $3 billion a year for the development of new computer software, Davis finds reliability inadequate for DOD applications.

No second chances

Current software standards simply do not guarantee devices that conform to the DOD's reliability and performance specifications. These stringent specifications apply to systems that often operate in uncontrolled environments and are often expendable; such systems require extremely compact hardware and software that must remain bug free and protected from undocumented change. Some devices, such as guided missiles, must work the first time, leaving no margin at all for error.

Davis contends that the software industry is now unprepared to meet the military's needs. The industry's emphasis has been on general-purpose, multifunction computer systems, but the DOD wants to develop fault-free software in real-time computer systems for few-function applications.

Davis plans to exploit "solid-state software" (ROM-based code) for the DOD's applications. The advantages are obvious: immunity to uncontrolled change and easy replaceability. In addition, because of the nature of ROM-based software, producers would have to achieve satisfactory reliability and performance.

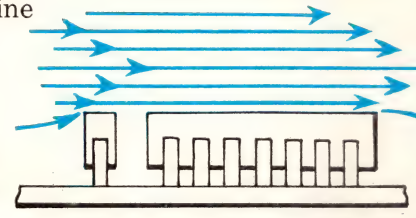
Another phase of Davis'

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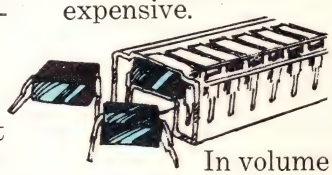
The typical radial capacitor is about twice the height above the circuit board as the IC package it is protecting. But at that height, it's also blocking the flow of cooling air. This leads to component failures. Or, it requires you to increase fan capacity, greater board spacing and other design inefficiencies.

DIPGuard, on the other hand, has the same seated height as the IC package, a mere 0.175 inches. There's far less blocking of air circulation and, therefore, far more efficient cooling throughout the system.



DIPGuards offer another significant advantage. Because they have the same height and same lead spacing as the IC packages that you insert automatically, you can expect lower circuit board assembly cost.

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software initiative would introduce "more mathematical rigor in defining system functions. These parameters would be translated into algorithms for implementation and functional fidelity checks." The proposal would accomplish what she calls "the test of software accountability": A computer system must perform its intended functions and not perform any unintended ones.

She believes a DOD collaboration with the industrial and academic communities will facilitate the use of automatic programming for chip design and test, leading to less expensive, reliable ROM-based software.

If the DOD's initiative motivates the software industry to investigate other applications besides those in general-purpose systems, Davis maintains software's current military deficiencies can be eliminated — to the benefit of *all* computer users. **EDN**

Small, lightweight oscilloscopes take the heft out of measurements

Andy Santoni,
West Coast Editor

Nowadays, you don't have to lug around a 30-lb instrument every time you require an oscilloscope; there are a number of miniscopes on the market—each weighing 15 lbs or less (some even less than 4 lbs)—that fit into a briefcase. And you don't have to make extensive compromises on features or accuracy to gain portability.

You can choose miniscopes with bandwidths as wide as 35 MHz—some with built-in digital multimeters or DMM/counters—or select instruments with storage.

The newest miniscope—Ballantine's Model 1022—has most of the features of standard oscilloscopes in its price range (about $900), but it weighs only 4 lbs and dissipates only 10W. To a large extent, explains design leader Ed Marrie, the unit's low power dissipation results from the use of a pulse - width - modulated switching power supply and



An extremely compact DMM/scope combination, *Tektronix's Model 213 displays resistance, current and voltage measurements on a digital readout and also shows current and voltage measurements on its CRT screen.*



Counter, DMM and 35-MHz oscilloscope *are integrated into a single 14-lb package in Vu-Data's Model PS935/975. The instrument costs less than $2000.*

an "old-fashioned" CRT—a short, curved-face unit with one 1-kV accelerating voltage, rather than the flat-faced, dual-accelerated units used in most modern scopes.

This 3-in. CRT delivers a bright, distortion-free trace without corona, although its beam current must be ten times that of 3-kV tubes. While it's inherently insensitive—requiring higher gain in the vertical, horizontal and blanking circuits—it offers the added advantage of a thin glass face, so a 4×5-cm graticule can be screened on the outside, limiting parallax error without the added cost of an internal graticule.

Bandwidth on the 1022 is better than 10 MHz; rise time, less than 30 nsec. Sensitivity ranges from 5 mV/div to 2V/div. Both the 2-channel 1022 and its single-channel Model 1021 cousin (costing about $150 less) are housed in a shielded plastic cabinet sealed

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against dust, dirt, oil and splashes.

Single- or dual-trace models

Tektronix offers a line of four miniscopes: single- and dual-trace models, a storage scope and a DMM/scope. The single-trace instrument, Model 221, provides a 5-MHz bandwidth and vertical sensitivities ranging from 5 mV/div to 100V/div. Priced at $995, this 3-1/2-lb unit includes an integral 1-MΩ probe and an internal battery that powers the scope for 3 hrs on one charge. The 221 even retains such large-scope features as X-Y operation and internal graticule.

If you often must compare two signals, you might choose Tektronix's dual-trace Model 212. Selling for $1080, this unit offers a fairly limited bandwidth—500 kHz for the 10-mV/div to 50V/div ranges and 100 kHz at 1 mV/div—but it does include features such as a pilot-light battery-charge indicator that extinguishes when the scope has about 10 min worth of operating power remaining in the batteries.

You can also obtain a storage version of the 212—in Tektronix's $1520 Model 214. This scope's bistable storage tube offers an 80-div/msec writing speed, with an enhanced mode that automatically increases single-sweep storage writing speed to 500 div/msec when you select a resolution setting between 0.1 msec/div and 5 μsec/div.

For the same price, Tektronix's Model 213 scope/DMM sports a 1-MHz bandwidth for deflection factors between 20 mV/div and 100 V/div, decreasing to 400 kHz for the 5- to 10-mV/div ranges. In addition, the scope displays current waveforms at frequencies up to 400 kHz for 20-μA/div to 100-mA/div deflection factors, decreasing to 200 kHz for 5- and 10-μA/div resolution settings. The unit's DMM provides true-rms measurements of voltage and current as well as measuring resistance—with 3-1/2-digit readings displayed on the scope's screen; DMM accuracy is ±0.1% of reading±1 count when measuring 1V dc FS.



A dual-trace miniscope for $435, *Non-Linear Systems' MS-215 responds at up to 15 MHz, but with limited accuracy.*

Measure frequency, too

Just as a built-in DMM facilitates and simplifies measurements associated with a scope's vertical scale, an on-board counter enables measurement of frequency without interpreting intervals on the horizontal axis. With this advantage in mind, Vu-Data offers a piggyback DMM/counter option, Model 975A, on two of its miniscopes: the 20-MHz, single-trace Model PS915A and the 35-MHz, dual-trace Model PS935.

The 975A's multimeter furnishes ac and dc voltage ranges from 2 to 1000V and resistance ranges from 2 to 2000 kΩ. It provides automatic upranging at a display of 1999 and downranging at 0100. The device's accuracy is within 0.5% of reading±1 digit on dc and ohms scales, and within 0.5% of reading±5 digits on ac ranges.

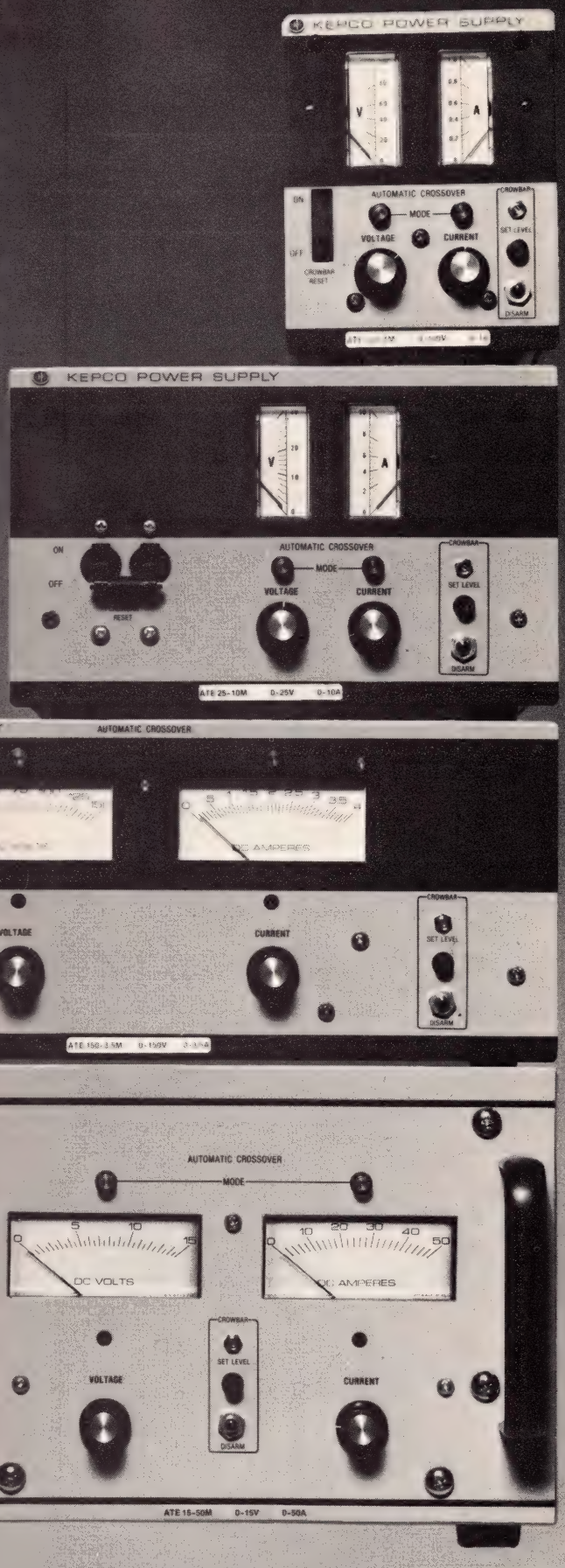
In Auxiliary DMM mode, the meter measures signals applied at the DMM terminals, while in Scope mode, the scope indicates signal voltage on channel 1. The on-board counter measures frequency with full-scale ranges from 9.999 kHz to 50 MHz; you select the required range manually.

Vu-Data's PS935 scope features 35-MHz bandwidth with a rise time less than 10 nsec and deflection factors ranging from 5 mV/div to 10 V/div. You can select either Alternate, Chopped or Add mode. The scope also provides a 100-nsec input delay line so you can see a signal's leading edge. The PS935 costs $1945 with the DMM/counter and $1545 without.

For a lower price ($1395) Vu-Data offers the 20-MHz, single-trace Model PS915A with the 975A DMM/counter; the lower priced

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scope alone costs $970. Like the PS935, this instrument operates from external ac or dc sources, as well as from an optional battery pack; recharging circuitry is built into the chassis.

Vu-Data also manufactures two dual-trace, 20-MHz miniscopes: the PS941B at $1245 and the PS943B—which includes a horizontal input—at $1295.

Spend less money

If you're concerned about cost, Non-Linear Systems' single-trace Model MS-15 (priced at $318) and dual-trace Model MS-215 (costing $435) qualify as the lowest priced miniscopes surveyed. These units provide external horizontal facilities and a bandwidth rated at 15 MHz.

The bandwidth specification, however, is measured at 6 dB down (instead of the traditional 3 dB) and with 1-div deflection (instead of the conventional full-screen). The 3-dB point occurs at 8 MHz with 2-div deflection; 2 MHz is the typical maximum frequency for a full-scale deflection of 4 div.

These NLS miniscopes operate for about 3 hrs from three sealed lead-acid cells before requiring a recharge from built-in circuitry. They also operate continuously from 115V-ac sources when connected via plug-in transformers.

These capabilities are not unique, however. Dumont Oscilloscope Labs' two miniscope models also offer internal rechargeable batteries and external ac/dc converters. The $540 Model 6010 and the $500 Model 6110 both offer 10-MHz bandwidth (at 3 dB down and full-scale deflection) and provide pulse rise times less than 35 nsec and overshoot or preswing specified at under 3%. In addition, both units furnish vertical ranges from 10 mV/div to 5V/div and horizontal sweep ranges extending from 0.1 μsec/div to 5 msec/div; the 6010 includes both line and field TV sync. **EDN**

Miniscope manufacturers

For more information on the products described in this article, contact these manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Ballantine Laboratories Inc
Box 97
Boonton, NJ 07005
(201) 335-0900
Circle No 445

Dumont Oscilloscope Laboratories Inc
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Non-Linear Systems Inc
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(714) 755-1134
Circle No 447

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Circle No 448

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(714) 279-6572
Circle No 449

IC image comparators, sonar devices eliminate out-of-focus photographs

Nikita Andreiev, Manager,
Midwest Editorial Office

Two techniques have finally brought commercially feasible automatic focusing to still cameras. One uses a compact sonar system; the other employs a specially developed linear IC that automatically compares two images of the subject to be photographed in much the same way a photographer compares split images when focusing manually.

The image-comparator IC, developed by Honeywell Inc, Minneapolis, MN, made possible the first commercially available automatic-focusing 35-mm still camera, the Konica C35AF. Honeywell has now licensed 15 other manufacturers to use the autofocus device.

It's all done with mirrors

The Honeywell system, termed Visitronic, utilizes

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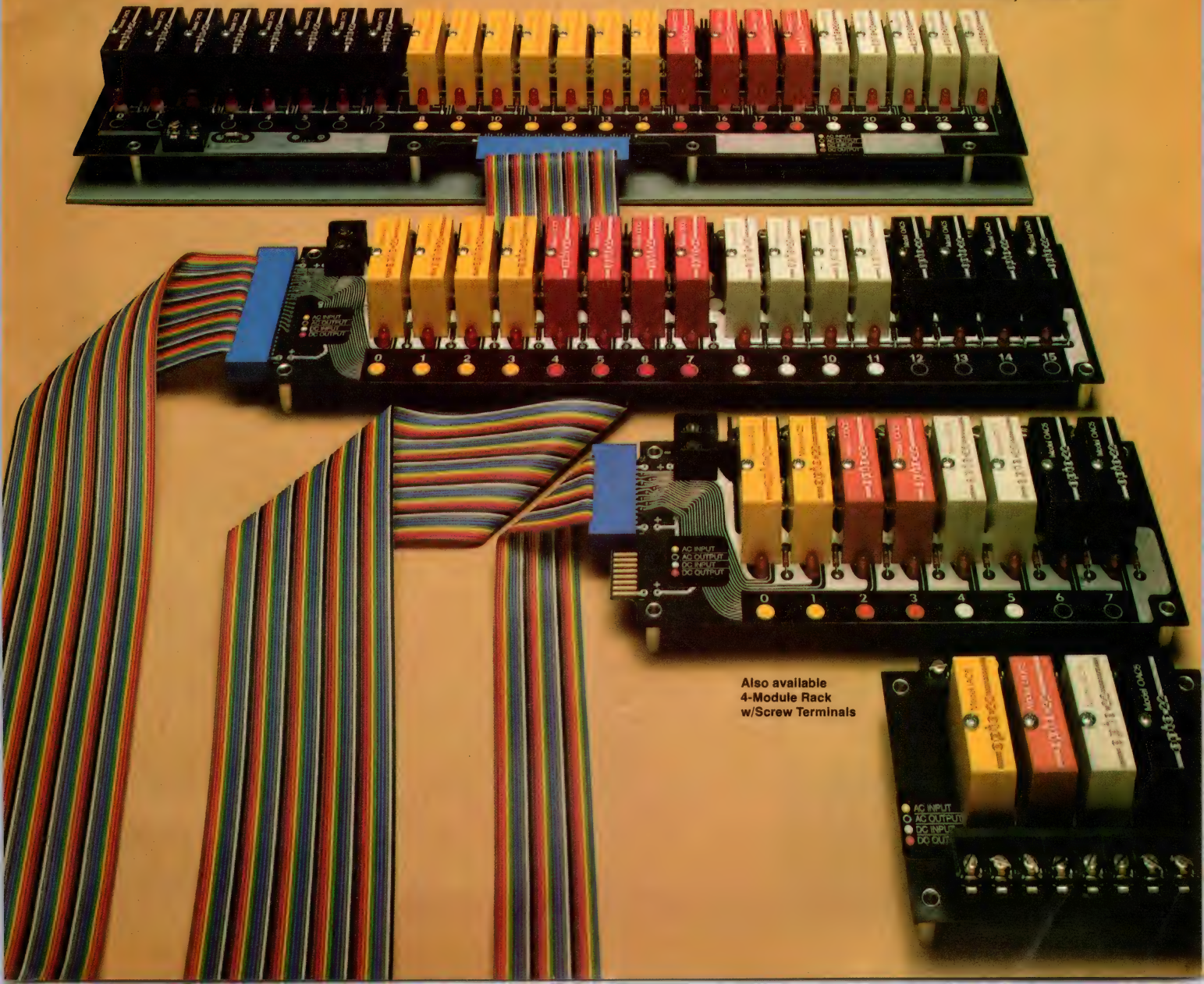
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- ☐ Motorola
- ☐ Burr-Brown
- ☐ Computer Automation
- ☐ Control Logic
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- ☐ Digital Equipment Corporation
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Describes various circuits that can be added to sensor to allow use as angular position, rate, or acceleration transducer.



Manufactured under license from Hercules, Inc., U. S. Patent 3,500,691

Humphrey Inc.

For more information, Circle No 33

News

optical triangulation to determine the optimum camera-lens focusing position. Two mirrors—one fixed and one movable—spaced a small distance apart behind windows on the camera front provide separate images of the subject to be photographed. Each image — focused by a lens and guided by a prism—projects onto one of two separate light-sensitive detector areas of the IC chip.

The system's movable mirror reflects a panorama of images (obtained through one camera window) for the Visitronic chip to compare with the fixed mirror's target image of the subject (obtained through the other camera window). As the mirror pivots through angles that correspond to triangulated distances ranging from 1.1m to infinity, one mirror position furnishes an image of the subject that most closely matches the target image.

The Visitronic chip, measuring approximately 2.5×6 mm, processes and compares the image from the movable mirror (falling on one detector) with the similar target image on the other detector. The resulting IC output signal represents a measure of image correlation, reaching a maximum when the images on both detectors are most nearly the same.

Segments see more

Rather than having the IC chip compare the outputs of the two light detectors on a one-to-one basis, Honeywell divided each detector into five vertical segments. The chip's processing portion therefore compares detector

Reader Service Index

D Subminiature Connectors



If the insert to the right has been removed please circle **Reader Service Card No. 119,** and we will rush a copy of the insert to you.

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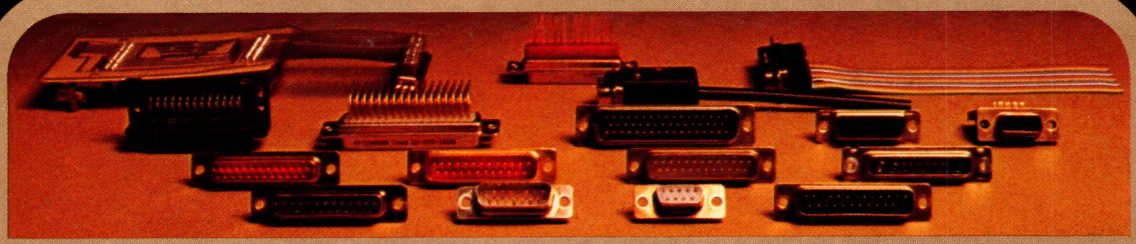
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The Cannon D Subminiature Store

PRODUCT OFFERING

CANNON'S GOT IT



PRODUCT LINE SUMMARY

SERIES	DESCRIPTION	DESIGNATION	INSULATORS	CONTACTS
D*	D Subminiature connector, low cost	ORIGINAL-D	Two-piece white Nylon	Solder, Wire-Wrap* and printed circuit
D*C	D Subminiature connector, low-cost for commercial applications	BURGUN-D (Mark IV)	Two piece, burgundy glass-filled Nylon	Crimp, snap-in rear release & printed circuit. Plastic cone retention.
D*U	Flame-retardant D Subminiature	BURGUN-D (Mark IV)	Two piece, black glass-filled Nylon (UL rated 94V-O)	Crimp snap-in, rear release & printed circuit. Plastic cone retention.
D*P	All-plastic 90° p.c.b. D Subminiature	BURGUN-D (Mark IV)	Black glass-reinforced thermo-plastic, UL rated 94V-O) (flame retardant)	Stamped printed circuit
D*M	D Subminiature connector for more critical applications conforms to MIL-C-24308	GOLDEN-D (Mark I)	Monobloc, dark green, Diallylphthalate glass-filled	Solder, printed circuit, Wire-Wrap* Coaxial, high power and high voltage.
D*MA	D Subminiature with LITTLE CAESAR® contact retention system conforms to MIL-C-24308	ROYAL-D (Mark III)	Monobloc, dark green, Diallylphthalate glass-filled	Crimp snap-in, rear release, coaxial and/or high voltage.
D*SP	Mass Terminated D Subminiature pin & socket connector	Mas/Ter-D (Mark V)	Black glass-reinforced thermo-plastic, UL rated 94V-O (flame retardant)	Non-removable insulation displacement termination.

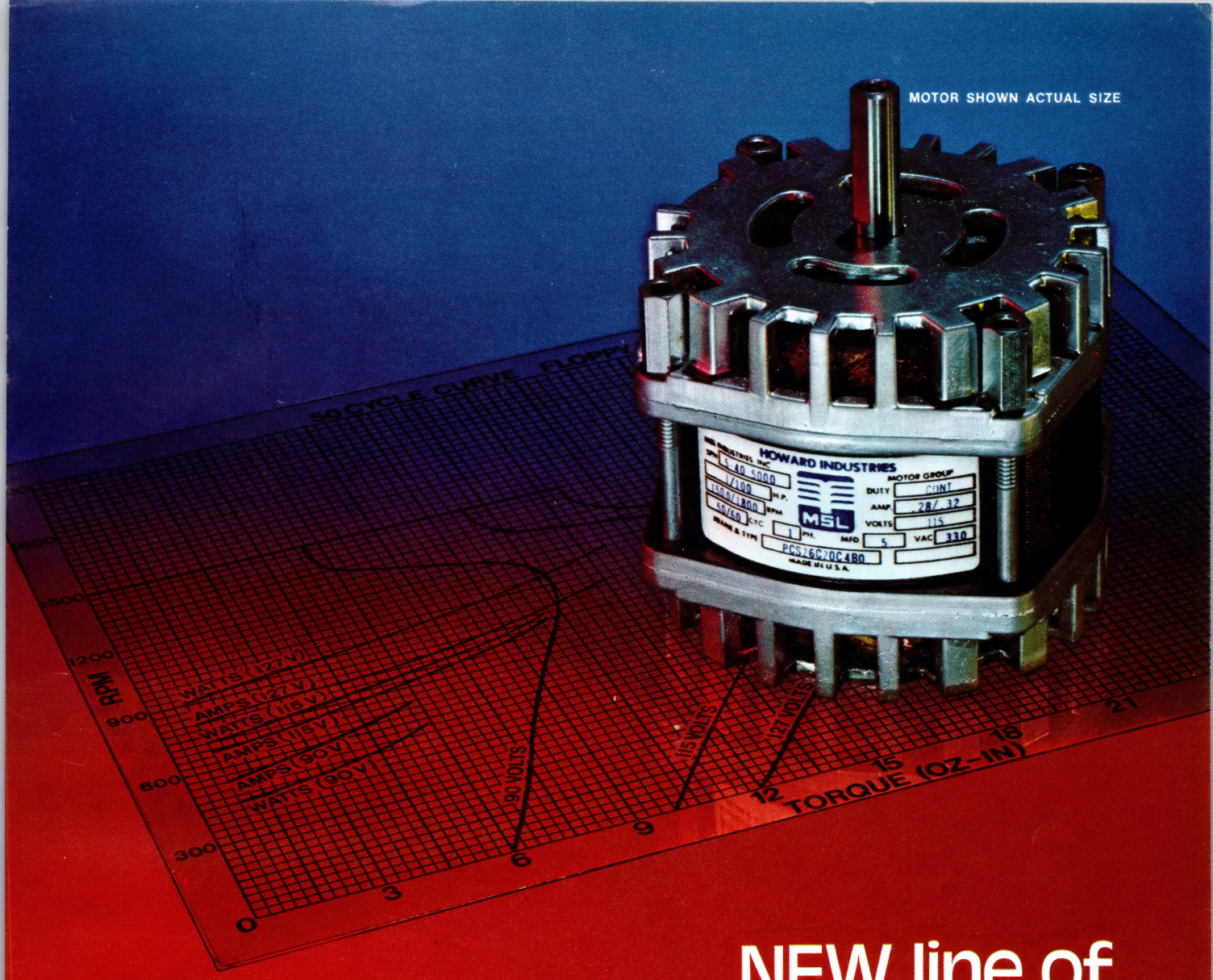
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Welcome to the ITT Cannon Electric D Subminiature store...Feel free to look around among one of the broadest lines of high quality, high reliability subminiature rectangular connectors found anywhere. Our store has been around for 60 years, serving industry worldwide. During that time customers have used billions of Cannon® D Subminiature connectors, contacts, and associated accessories and tooling. Why billions? Because people appreciate quality, and that's the concern of everyone in the ITT Cannon family. From the president to the assembly worker, we've a dedication to doing things right the first time. That's why our Quality Assurance department guarantees the high reliability of our products in meeting industry standards and MIL-Spec demands. And we're proud that this dedication is reflected in the numerous customer awards for excellence that we've received.

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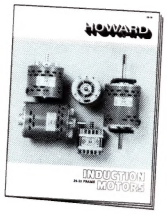
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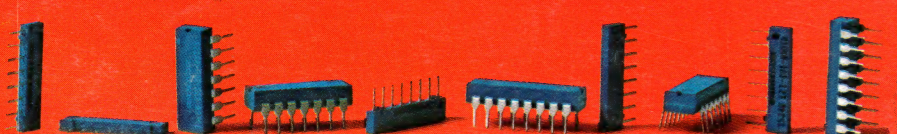
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